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FLAME- AND SMOKE-RETARDANT POLYMER SYSTEMS. (U)

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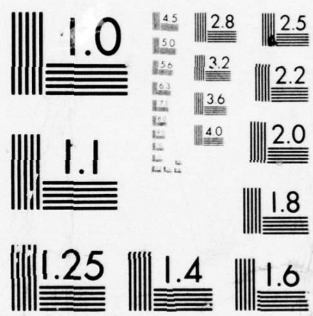

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FLAME- AND SMOKE-RETARDANT POLYMER SYSTEMS

Second Quarterly Report

Issued: 26 April 1977

Period Covered: August — October 1976

Prepared Under Contract: N00024-76-C-5336

For

Department of the Navy
Naval Sea Systems Command
Washington, DC 20362

Leo Parts and Catherine A. Thompson

MONSANTO RESEARCH CORPORATION
A SUBSIDIARY OF MONSANTO COMPANY

Monsanto

DAYTON LABORATORY

DAYTON, OHIO 45407

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ABSTRACT

Experimental smoke-retardant PVC compositions and a reference base polymer were coated with alkyd- and epoxy-based intumescent paints. Specimens were tested in an NBS smoke density chamber under flame and nonflame exposure conditions. The smoke optical density, and the concentrations of CO, CO_2, NO_x, hydrocarbons, hydrogen chloride and oxygen were monitored during these tests.

Although the coatings reduced smoke formation from the base polymer, they had an adverse effect on the performance of the smoke-retardant compositions. The commercial coatings used in this work were found to generate significant quantities of smoke. Other, recently developed coatings will be used in projected work.

The intumescent coatings reduced the rates of carbon monoxide and hydrogen chloride formation, especially under nonflame exposure to a radiant energy source.

The coatings contributed small amounts of nitrogen oxides (NO_x) to the combustion products.

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1. INTRODUCTION

Means for enhancing the fire safety of two polymeric materials, plasticized polyvinyl chloride (PVC) and Neoprene, are investigated in this program. As reported in our first quarterly report (Ref. 1) ferric and cupric acetylacetonates were found to reduce smoke formation from PVC, in terms of optical density, by approximately 55%. In an attempt to further enhance the fire performance of these compositions, they were coated with intumescent compositions. Data for the formation smoke and gaseous combustion products from these compositions, under controlled test conditions, are presented in this report. Flame propagation data will be presented in a subsequent report.

2. EXPERIMENTAL

2.1 MATERIALS

The base polymer (BP) formulation contained 30 phr of Santicizer 148 plasticizer, 7 phr of dibasic lead phthalate, 0.4 phr of dibasic lead stearate and 0.4 phr of stearic acid.

The flame- and smoke-retardant (FSR) formulations contained 30 phr $MgCO_3$ (Magcarb L, from Merck Chemical Division). Additionally, the formulations FSP-1 and FSP-2 contained also 5 phr ferric acetylacetonate and cupric acetylacetonate, respectively. The procedure for the preparation of the 0.16 cm thick sheets of the three polymer compositions was reported previously (Ref. 1).

Two types of intumescent coatings, an alkyd- and an epoxy-based material, were used. These were applied onto one side of the molded PVC sheet specimens and of a 0.019 in. thick aluminum sheet according to the manufacturers' specifications. The alkyd-based intumescent coating (No. 110 by C. M. Athey Paint Company) is designated as IC-1 in the present data tabulations. The epoxy-based coating (No. 477 by Ocean Chemicals, Inc.) is identified by the suffic IC-2. The alkyd-based coating is recommended by its manufacturer for interior surfaces (e.g., galleys, and engine room bulkheads and overheads) of marine vessels (Ref. 2). The epoxy-based intumescent coating is recommended for interior, exterior, and marine applications (Ref. 3)

The intumescent coatings were applied with a brush in approximate thicknesses specified in the manufacturers' technical literature. The alkyd coating is applied at a coverage of 200 square feet per gallon in a single application. The epoxy coating is recommended at a thickness of 9 to 10 mils, which is attained in two applications, at a total coverage rate of approximately 130 square feet per gallon. The solids content of the epoxy coating is in excess of 80%.

The alkyd coating was allowed to dry at room temperature for one week and the epoxy coating for at least two weeks before specimens were cut for testing. The thickness of the dried alkyd coating was approximately 15 mils; the corresponding value for the epoxy coating was 9 mils.

2.2 TEST METHODS FOR THE FORMATION OF SMOKE AND GASEOUS COMBUSTION PRODUCTS

An analysis system capable of continuous measurement of CO, CO_2, NO_x, total hydrocarbons and oxygen (Ref. 4) during the burning of polymers was used in conjunction with smoke measurements. This system, designed and constructed at Monsanto Research Corporation (MRC), is connected to the NBS-Aminco smoke density chamber, that is utilized for the burning of samples under controlled conditions. The apparatus and the test methods were described in some detail in the preceding quarterly report (Ref. 1). The sample sizes and the test conditions were identical with those specified in that report.

3. RESULTS AND DISCUSSION

3.1 FORMATION OF SMOKE

The primary objective of the present program is to lower smoke formation from burning PVC and Neoprene polymer compositions. Concomitantly, enhancement of other fire performance characteristics (e.g., reduction of the rate of flame propagation) will be sought.

Previous work at MRC (Ref. 5 and 6) and elsewhere (Ref. 7) has demonstrated the effectiveness of intumescent coatings for enhancing the fire performance of some polymers. Upon exposure to heat, the intumescent coatings expand to 100-300 fold of their original thicknesses, forming insulating cellular structures that afford protection to the substrate. Reduction of smoke formation and of flame propagation has been attained with intumescent coatings. In the present work, it was sought to investigate the effectiveness of that approach with the FSR PVC compositions.

Both types of intumescent coatings used in the present work, were found to reduce smoke formation from the base polymer, in terms of its maximum optical density, by approximately 20% (see Figure 1). However, when these coatings were applied onto the fire- and smoke-retardant compositions FSP-1 ans FSP-2, they had an adverse effect on smoke formation (see Table I and Figures 2-6). It appeared that with these materials, of lower smoke formation propensity than the base polymer, the coatings contributed smoke upon exposure to the radiant energy source and to the flame.

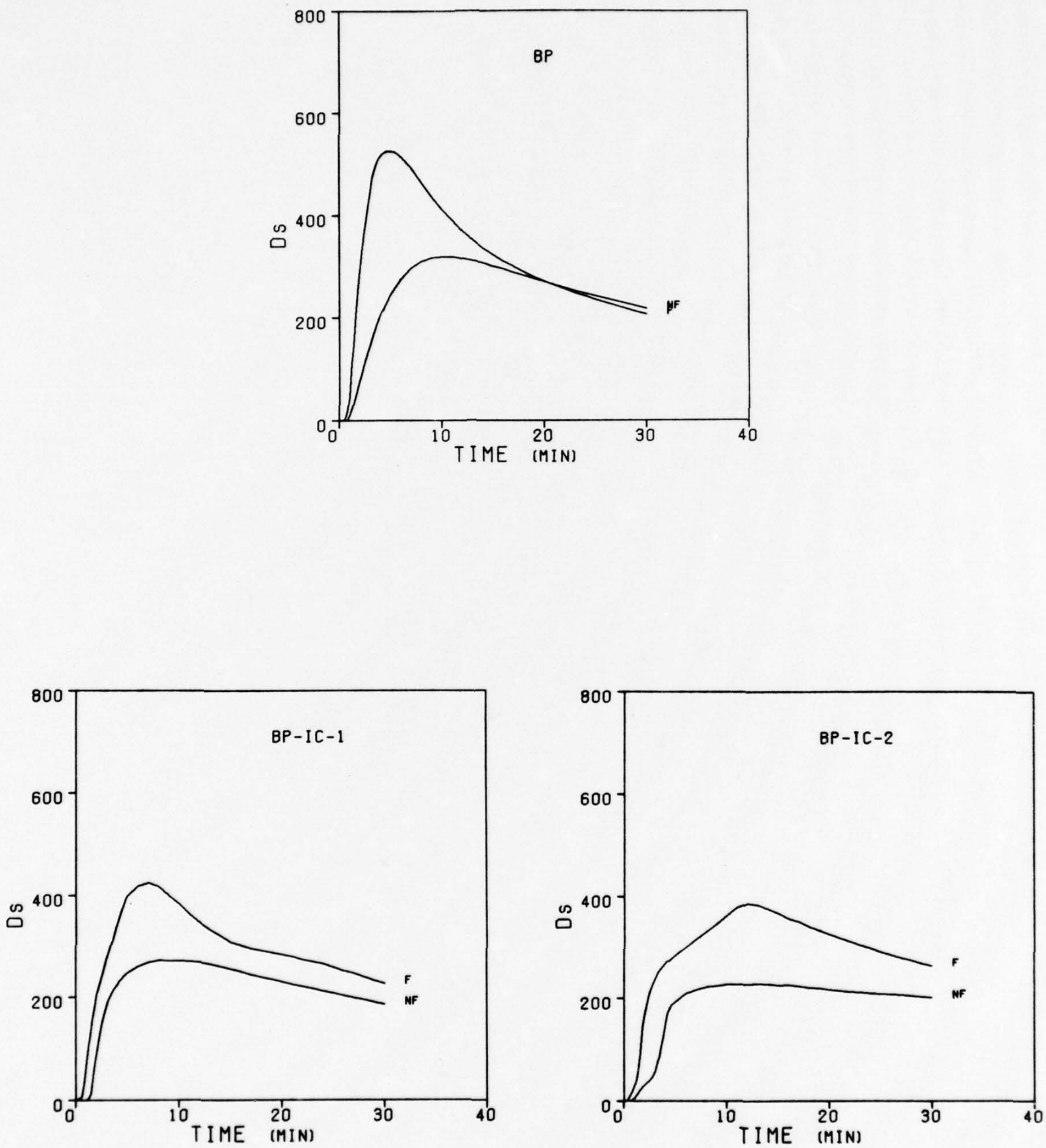

Figure 1. Smoke Optical Densities During the Burning of BP-IC Compositions

Table I

SMOKE OPTICAL DENSITY RESULTS SUMMARY FOR PVC COMPOSITIONS[a]

	Smoke Optical Density (SOD)						Time to Maximum SOD (min)	
	Flame Exposure			Nonflame Exposure				
Material	10 min	20 min	Maximum	10 min	20 min	Maximum	Flame Exposure	Nonflame Exposure
BP	410	270	510	320	270	320	4	10
FSP-1	185	135	200	180	155	185	6	12
FSP-2	140	105	165	150	115	155	5	8
BP-IC-1	380	280	420	270	230	270	7	8
BP-IC-2	360	320	390	230	220	230	12	13
FSP-1-IC-1	200	180	200	195	190	200	11	15
FSP-1-IC-2	340	260	380	270	270	270	7	16
FSP-2-IC-1	200	135	250	180	150	180	6	12
FSP-2-IC-2	410	320	420	270	240	270	9	10
IC-1[b]	59	87	100	48	68	76	30	30
IC-2[b]	165	130	188	86	99	97	7	17

[a]Measurements conducted with 7.6 cm x 7.6 cm x 0.16 cm specimens in vertical orientation. Imposed energy flux in the center of the samples 2.5 watts/cm^2.

[b]Intumescent coating on an aluminum substrate, whose dimensions were 7.6 cm x 7.6 cm x 0.042 cm.

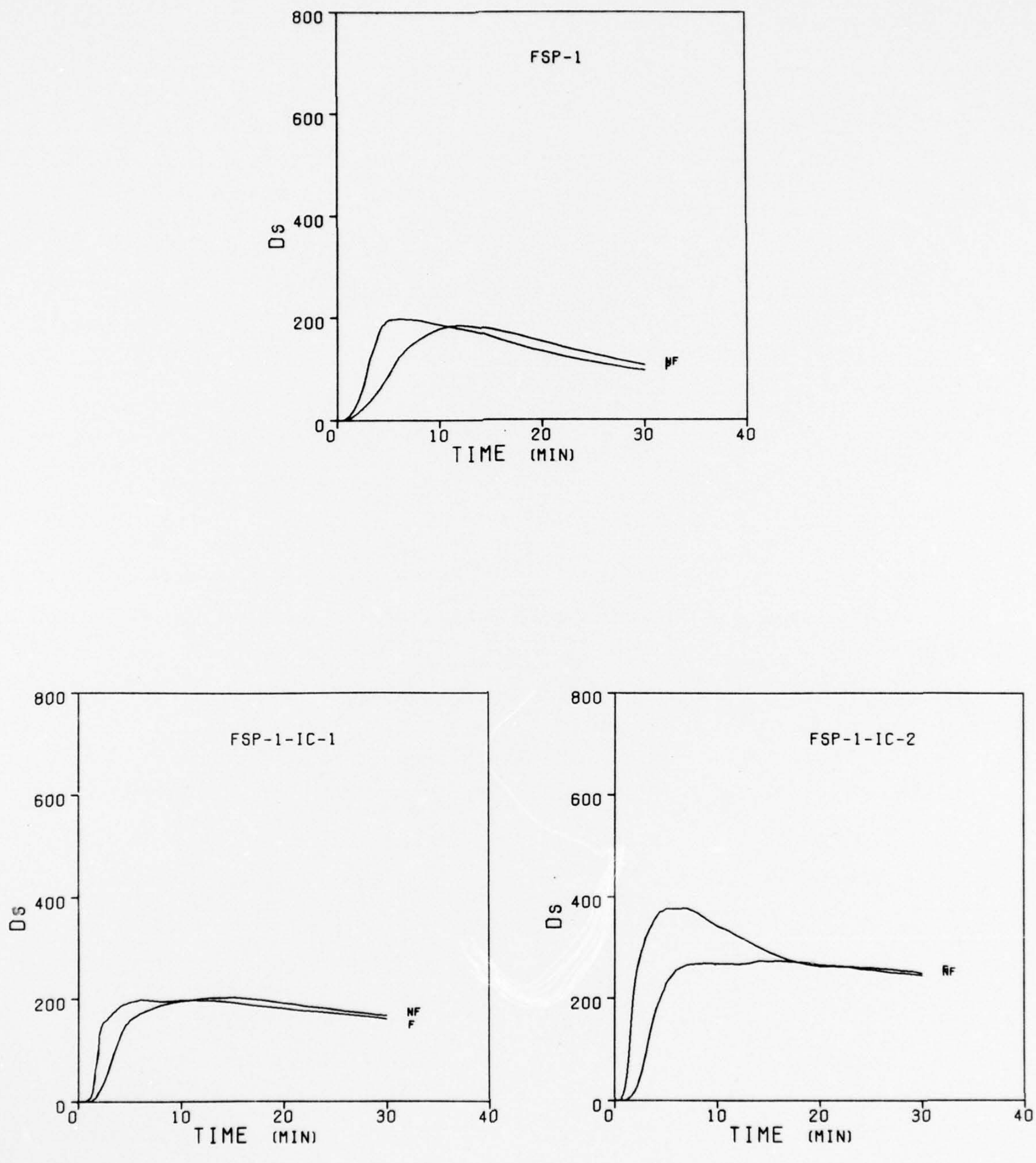

Figure 2. Smoke Optical Densities During the Burning of FSP-1-IC Compositions

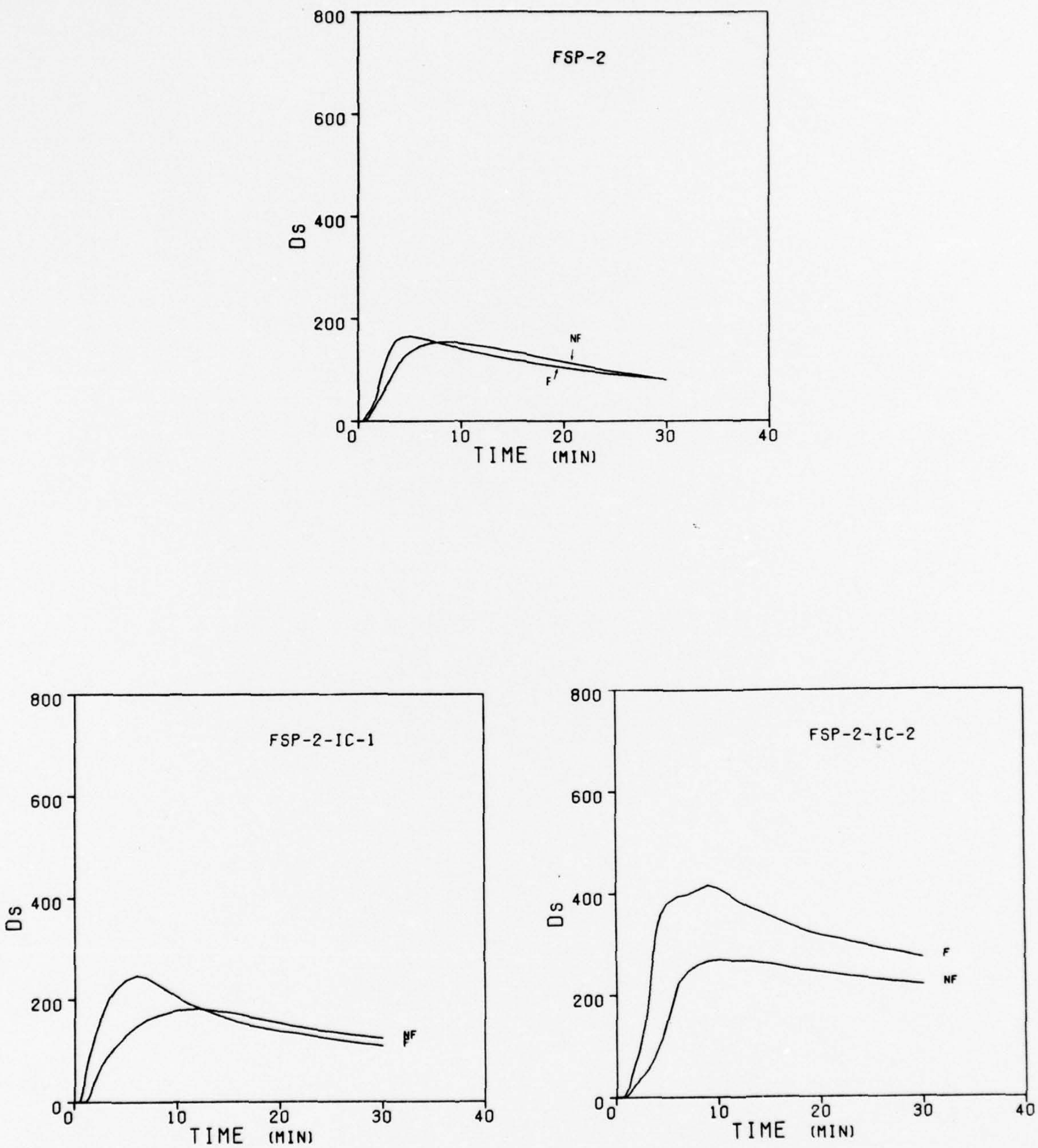

Figure 3. Smoke Optical Densities During the Burning of FSP-2-IC Compositions

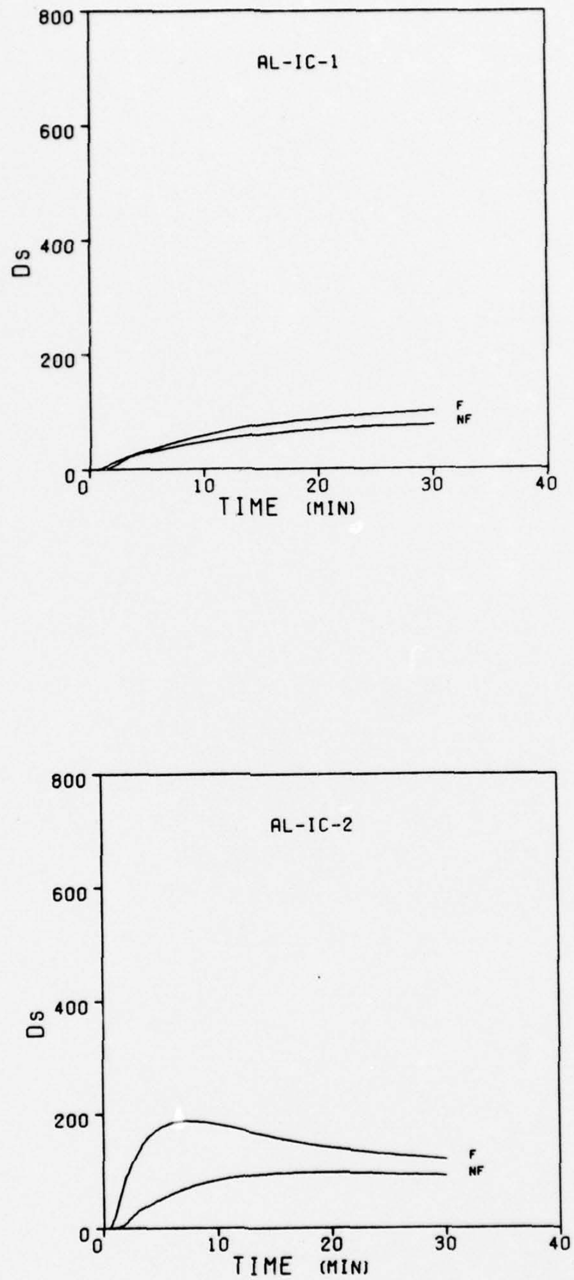

Figure 4. Smoke Optical Densities During the Exposure of Al-IC Compositions

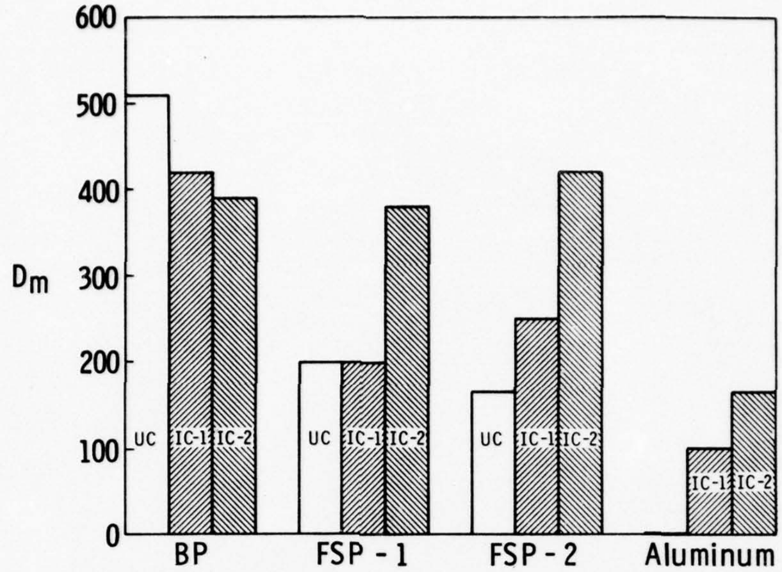

Figure 5. Maximum Specific Smoke Optical Densities Under Flame Exposure Conditions

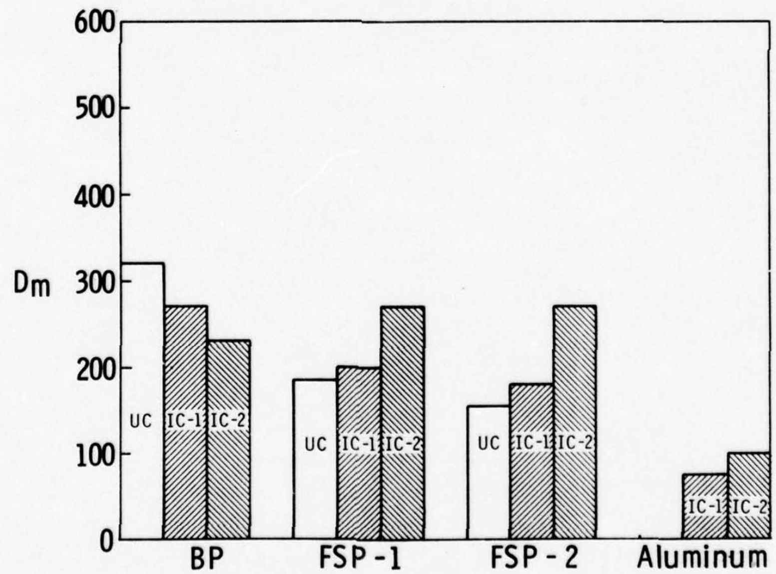

Figure 6. Maximum Specific Smoke Optical Densities Under Nonflame Exposure Conditions

Tests were subsequently conducted with thin aluminum sheet specimens that had been coated with intumescent paints. These tests demonstrated (see Figures 5 and 6) that the adverse effect, which was found to be especially pronounced with the epoxy-based material, indeed arose from smoke generated by the coating itself upon sustained exposure to the radiant energy source and to the flame.

The above results indicate need for intumescent coatings of very low propensity for smoke formation, to utilize fully the effectiveness of smoke-retardant additives incorporated into polymers. Some new candidate materials have recently been developed (Ref. 8). These merit experimental evaluation with the FSR PVC compositions developed in the present program.

With regard to the rates of smoke formation, it was generally found that they were reduced by the intumescent coatings.

3.2 FORMATION OF GASEOUS COMBUSTION PRODUCTS

The intumescent coatings reduced significantly the formation of carbon monoxide under nonflame exposure conditions (see Table II and Figures 7-9). This effect was especially noticeable with the FSP-1 composition.

The maximum concentrations of carbon monoxide formed under flame exposure conditions were not greatly affected by the coatings. However, it should be noted that significant carbon monoxide concentrations were generated under flame exposure conditions from the two intumescent coatings used in this work (see Figure 10). The formation of carbon monoxide from these coatings is attributed to the oxidation of the initially formed carbonaceous chars in the flame.

The formation of carbon dioxide from the FSP compositions was retarded by the intumescent coatings under the nonflame exposure conditions (see Table III).

The intumescent coatings enhanced slightly the formation of NO_x under both types of exposure conditions; however, they delayed the time when the maximum concentrations were reached. The epoxy coating enhanced NO_x formation more than the alkyd coating used in this work (see Table IV and Figures 15-18 in the Appendix).

The insulating coatings reduced the rate of hydrogen chloride formation, especially under nonflame exposure to the radiant energy source.

The feasibility of retaining the smoke-retardant characteristics of the FSP compositions, and enhancing other fire safety properties with recently developed instumescent compositions will be investigated in projected work.

Table II

SUMMARY OF CO CONCENTRATION DATA FOR SELECTED TIMES FOR PVC COMPOSITIONS

Material	CO Concentration (ppm)						Time to Maximum CO Concentration (min)	
	Flame Exposure			Nonflame Exposure				
	10 min	20 min	Max. Conc.	10 min	20 min	Max. Conc.	Flame Exposure	Nonflame Exposure
BP	810	1450	1900	120	310	570	30	30
FSP-1	1190	1850	2200	170	960	1350	30	30
FSP-2	1030	1700	2100	220	700	850	30	30
BP-IC-1	910	1400	1850	50	153	230	30	30
BP-IC-2	700	1400	2000	23	92	180	30	30
FSP-1-IC-1	780	1700	2350	21	76	135	30	30
FSP-1-IC-2	880	1450	2050	35	125	210	30	30
FSP-2-IC-1	750	1300	1600	36	141	235	30	30
FSP-2-IC-2	590	1300	1950	32	115	200	30	30
IC-1	185	550	1400	3	12	25	30	30
IC-2	185	350	520	6	13	20	30	30

Table III

SUMMARY OF CO_2 CONCENTRATION DATA FOR SELECTED TIMES FOR PVC COMPOSITIONS

Material	CO_2 Concentration (%) Flame Exposure 10 min	Flame Exposure 20 min	Flame Exposure Max. Conc.	Nonflame Exposure 10 min	Nonflame Exposure 20 min	Nonflame Exposure Max. Conc.	Time to Maximum CO_2 Concentration (min) Flame Exposure	Nonflame Exposure
BP	0.68	1.24	1.78	0.02	0.06	0.12	30	30
FSP-1	0.79	1.40	1.89	0.18	0.45	0.60	30	29
FSP-2	0.98	1.61	2.16	0.17	0.40	0.50	30	29
BP-IC-1	0.80	1.46	2.16	0.00	0.00	0.03	30	30
BP-IC-2	0.54	1.12	1.68	0.01	0.03	0.04	30	30
FSP-1-IC-1	0.79	1.11	1.40	0.07	0.13	0.16	30	30
FSP-1-IC-2	0.94	1.34	1.77	0.10	0.18	0.22	30	30
FSP-2-IC-1	1.00	1.67	2.32	0.11	0.16	0.20	30	30
FSP-2-IC-2	0.78	1.31	1.78	0.09	0.18	0.22	30	30
IC-1	0.44	0.75	1.05	0.02	0.02	0.03	30	30
IC-2	0.40	0.86	1.24	0.02	0.03	0.04	30	30

Table IV

SUMMARY OF NO_x CONCENTRATION DATA FOR SELECTED TIMES FOR PVC COMPOSITIONS

	NO_x Concentration (ppm)						Time to Maximum NO_x Concentration (min)	
	Flame Exposure			Nonflame Exposure				
Material	10 min	20 min	Max. Conc.	10 min	20 min	Max. Conc.	Flame Exposure	Nonflame Exposure
BP	13	9.4	19	2.9	2.2	4.6	5	4
FSP-1	2.5	2.8	3.3	1.5	1.4	1.8	30	5
FSP-2	5.9	5.3	7.7	1.5	1.4	1.6	5	4
BP-IC-1	27	35	40	3.6	7.9	12	30	30
BP-IC-2	21	36	46	11	12	16	30	30
FSP-1-IC-1	33	35	37	3.6	8.4	13	30	30
FSP-1-IC-2	42	49	54	5.0	11	16	30	30
FSP-2-IC-1	22	28	31	2.9	6.2	9.1	30	30
FSP-2-IC-2	33	50	60	5.0	11	16	30	30
IC-1	16	19	21	2.2	4.0	6.0	30	30
IC-2	24	38	46	6.1	7.9	9.5	30	30

Table V

SUMMARY OF HYDROCARBONS CONCENTRATION DATA FOR SELECTED TIMES FOR PVC COMPOSITIONS

Material	Hydrocarbons Concentration (ppm)[a] Flame Exposure 10 min	20 min	Max. Conc.	Nonflame Exposure 10 min	20 min	Max. Conc.	Time to Maximum Hydrocarbons Concentration (min) Flame Exposure	Nonflame Exposure
BP	4300	4600	5200	2800	2900	3000	30	17
FSP-1	2300	3000	3500	3400	3400	3500	30	13
FSP-2	2400	2600	2800	2900	2700	2900	30	14
BP-IC-1	4300	4400	4500	2600	3000	3000	24	19
BP-IC-2	5200	6200	6700	2200	3100	3100	30	20
FSP-1-IC-1	3700	5600	7100	1600	2500	2500	30	22
FSP-1-IC-2	3400	5500	7600	2500	3200	3200	30	18
FSP-2-IC-1	4200	4500	5000	3200	3300	3300	30	19
FSP-2-IC-2	3700	4500	5000	2100	3300	3400	29	21
IC-1	540	1750	2600	39	55	62	30	29
IC-2	660	800	830	310	360	360	25	20

[a]Determined by flame ionization measurement. Expressed in terms of methane equivalents.

Table VI

SUMMARY OF HCl CONCENTRATION DATA FOR SELECTED TIME FOR PVC COMPOSITIONS

	HCl Concentration (ppm)					
	Flame Exposure			Nonflame Exposure		
Material	5 min	15 min	30 min	5 min	15 min	30 min
BP	1950	2400	1050	1900	2600	2200
FSP-1	1900	2200	1500	1650	2400	2100
FSP-2	1350	900	490	1500	2300	1900
BP-IC-1	2100	1250	620	1650	1850	1900
BP-IC-2	1200	2200	1150	520	1750	1850
FSP-1-IC-1	1250	1950	1400	(160)	950	1300
FSP-1-IC-2	900	1100	910	(250)	(330)	(<63)
FSP-2-IC-1	1250	780	940	(78)	1200	1600
FSP-2-IC-2	(120)	(190)	(140)	220	1000	1000
IC-1						
IC-2	<63	<63	<63	<63	<63	<63

4. ACKNOWLEDGMENT

The authors are indebted to Mr. R. D. Myers for the compounding and molding of the PVC compositions. They also wish to express appreciation to Miss K. A. Flayler, Mr. J. T. Miller and Mr. N. F. May for computerized data processing.

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8. Personal communication from E. Goldsmith, Ocean Chemicals, Inc., 20 April 1977.

APPENDIX

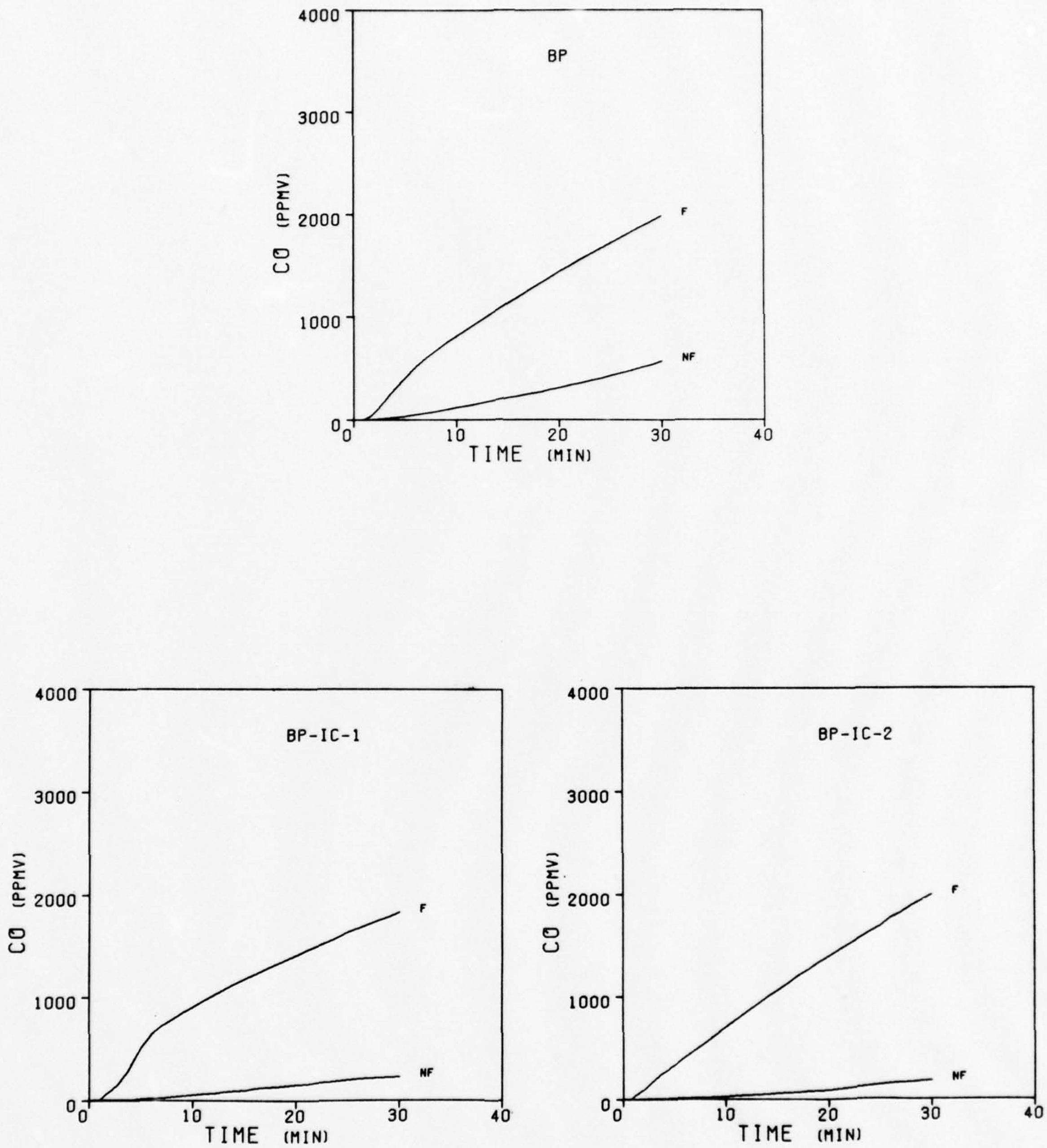


Figure 7. Carbon Monoxide Concentrations During the Burning of BP-IC Compositions

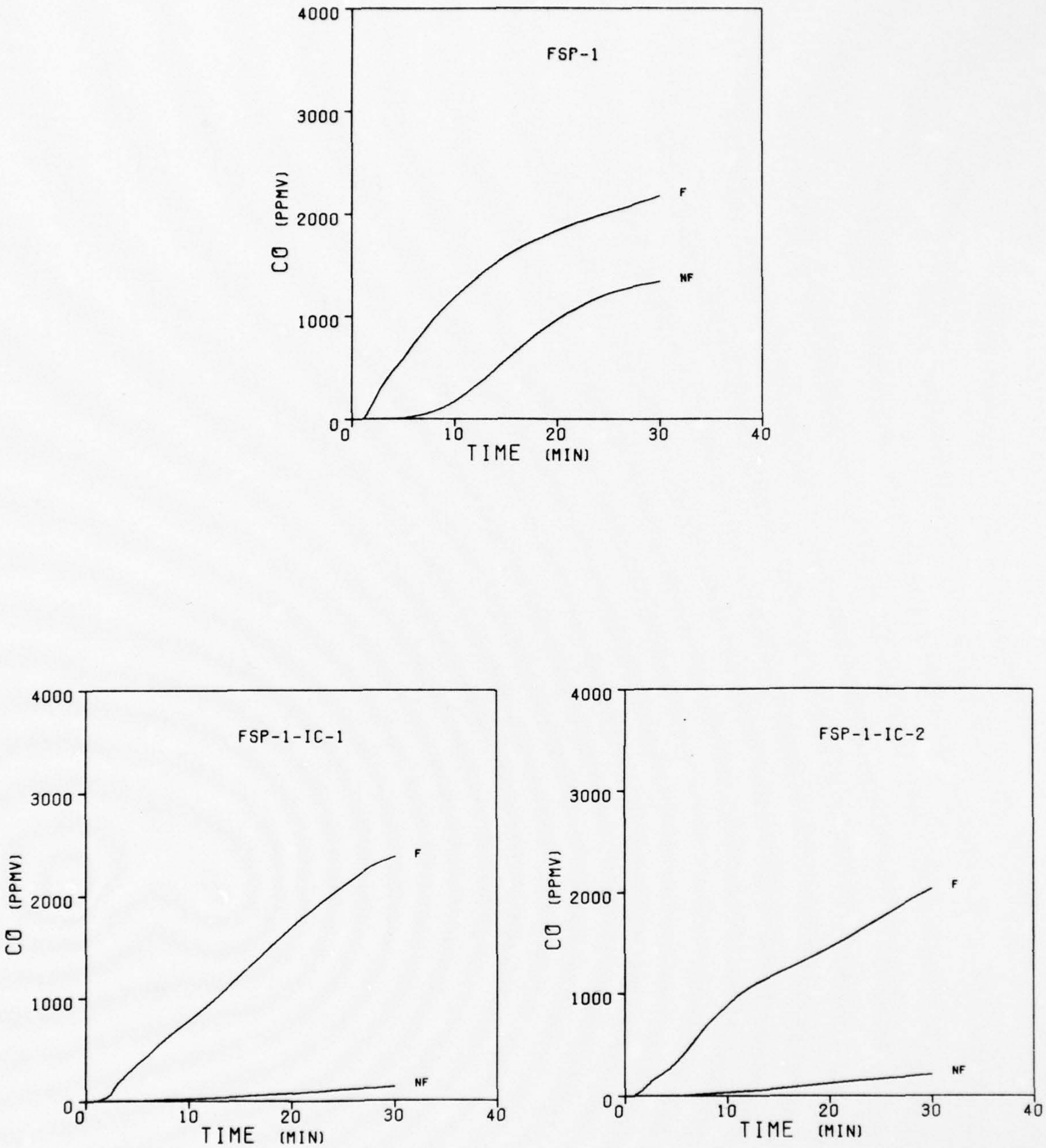


Figure 8. Carbon Monoxide Concentrations During the Burning of FSP-1-IC Compositions

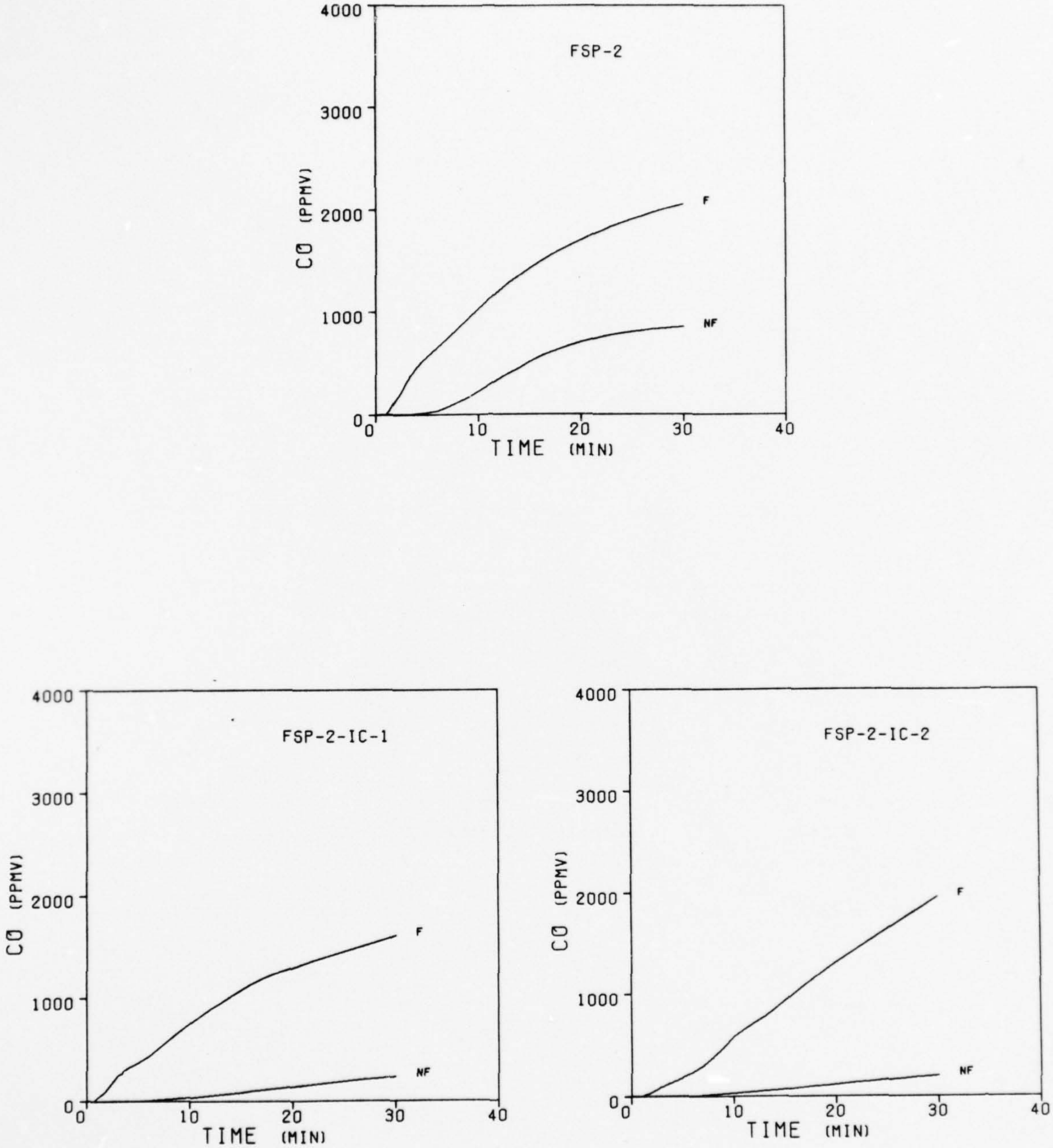
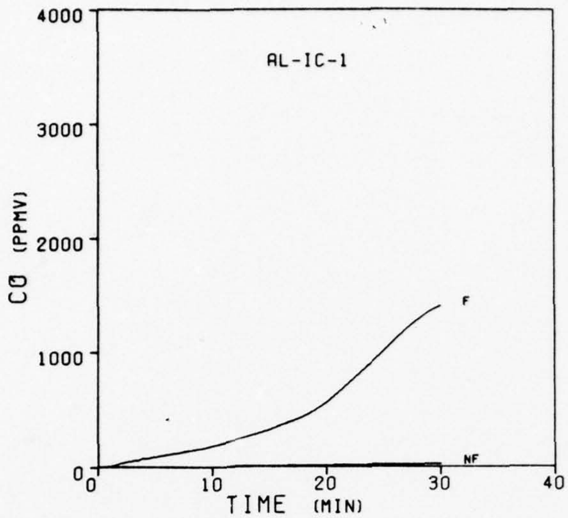


Figure 9. Carbon Monoxide Concentrations During the Burning of FSP-2-IC Compositions



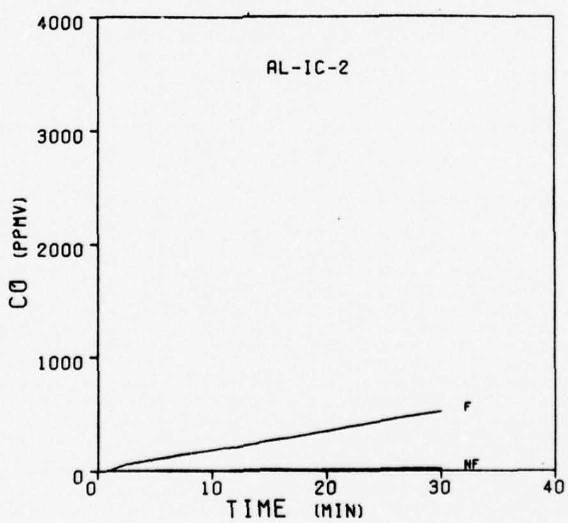


Figure 10. Carbon Monoxide Concentrations During the Exposure of Al-IC Compositions

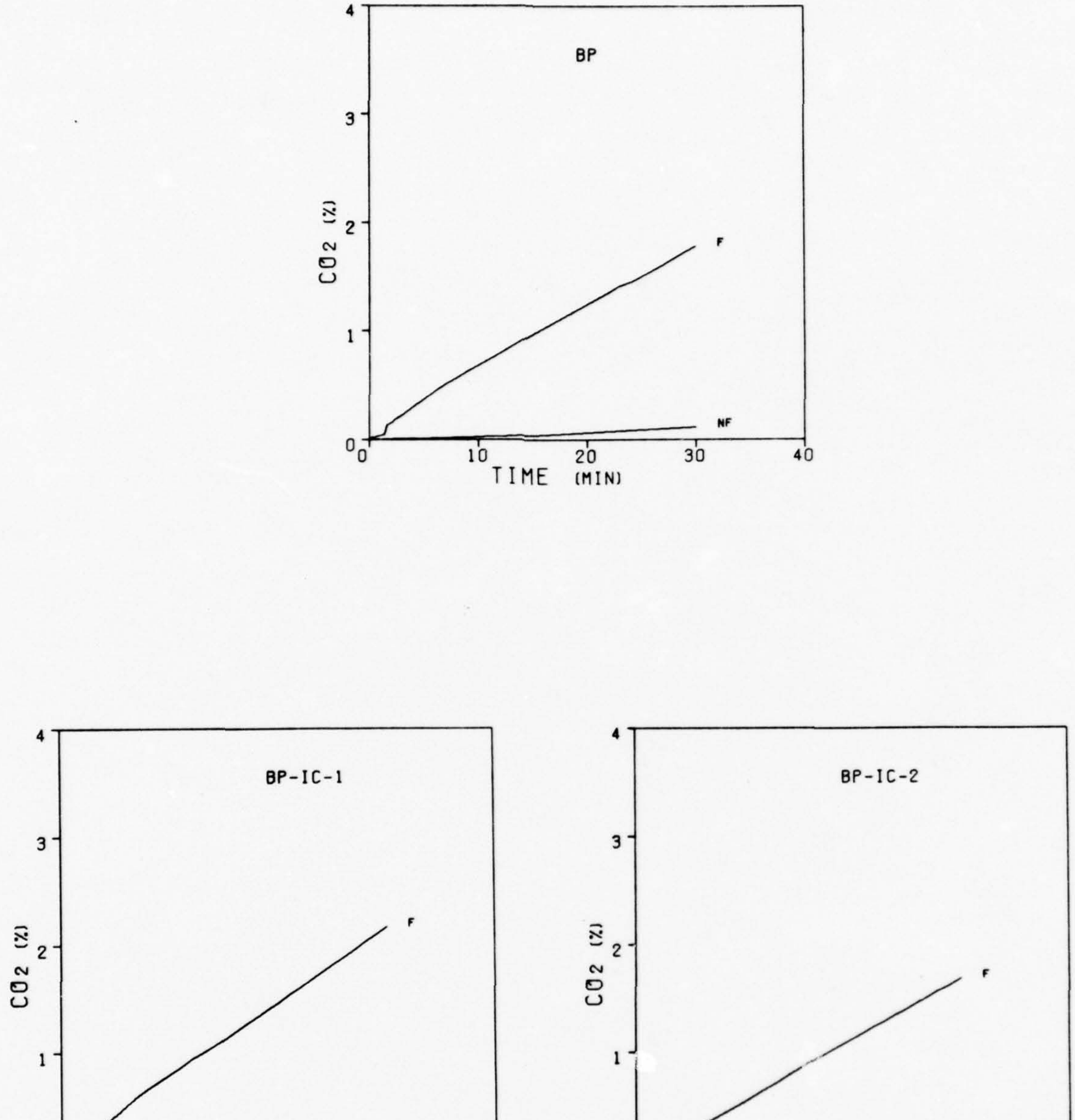


Figure 11. Carbon Dioxide Concentrations During the Burning of BP-IC Compositions

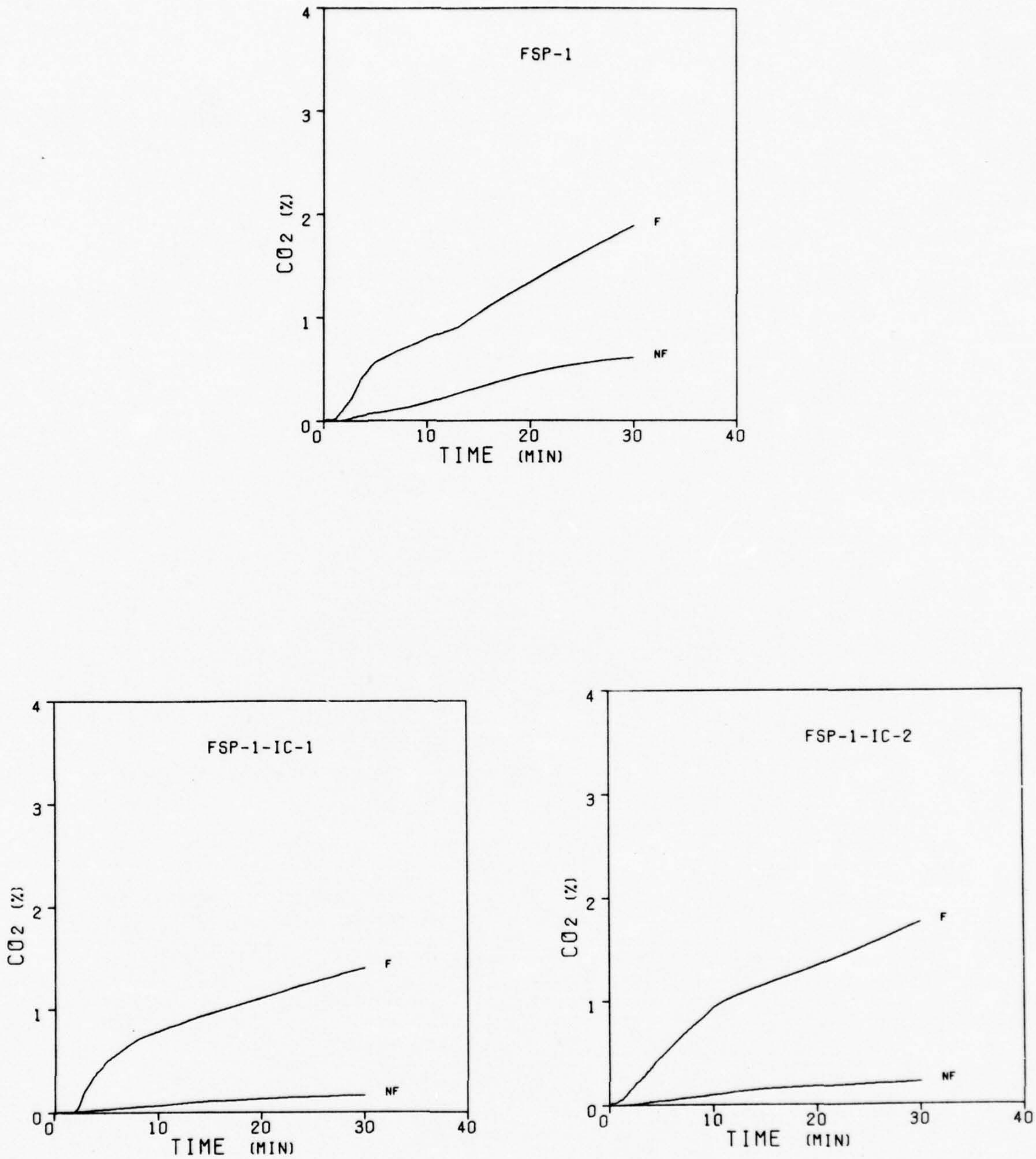


Figure 12. Carbon Dioxide Concentrations During the Burning of FSP-1-IC Compositions

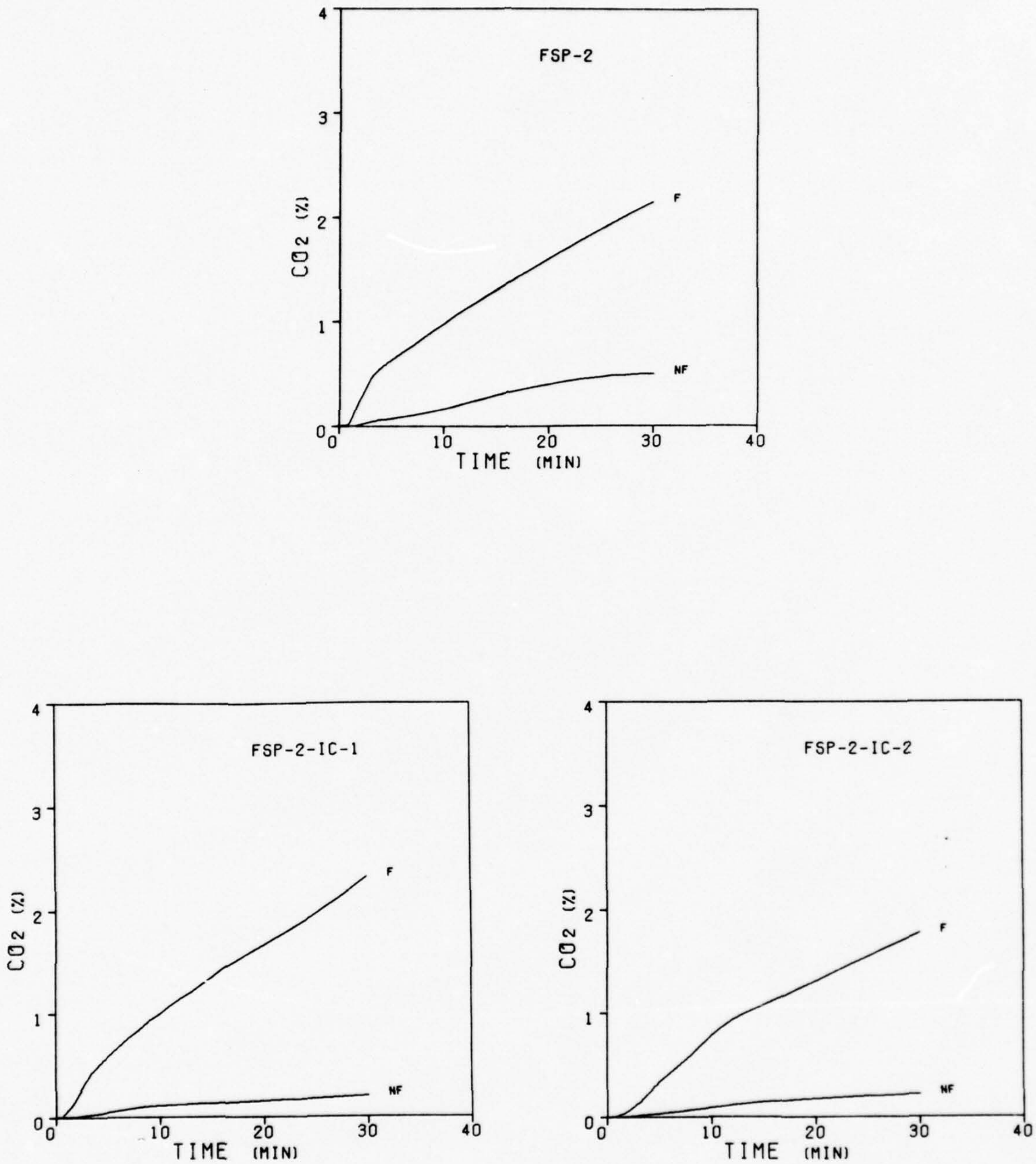


Figure 13. Carbon Dioxide Concentrations During the Burning of FSP-2-IC Compositions

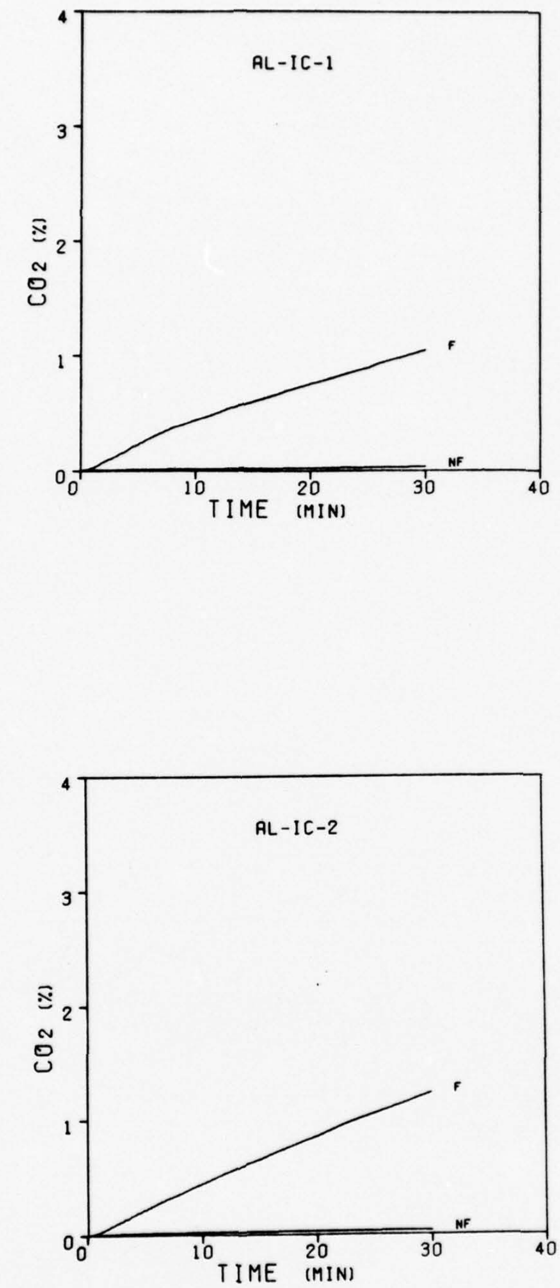


Figure 14. Carbon Dioxide Concentrations During the Exposure of Al-IC Compositions

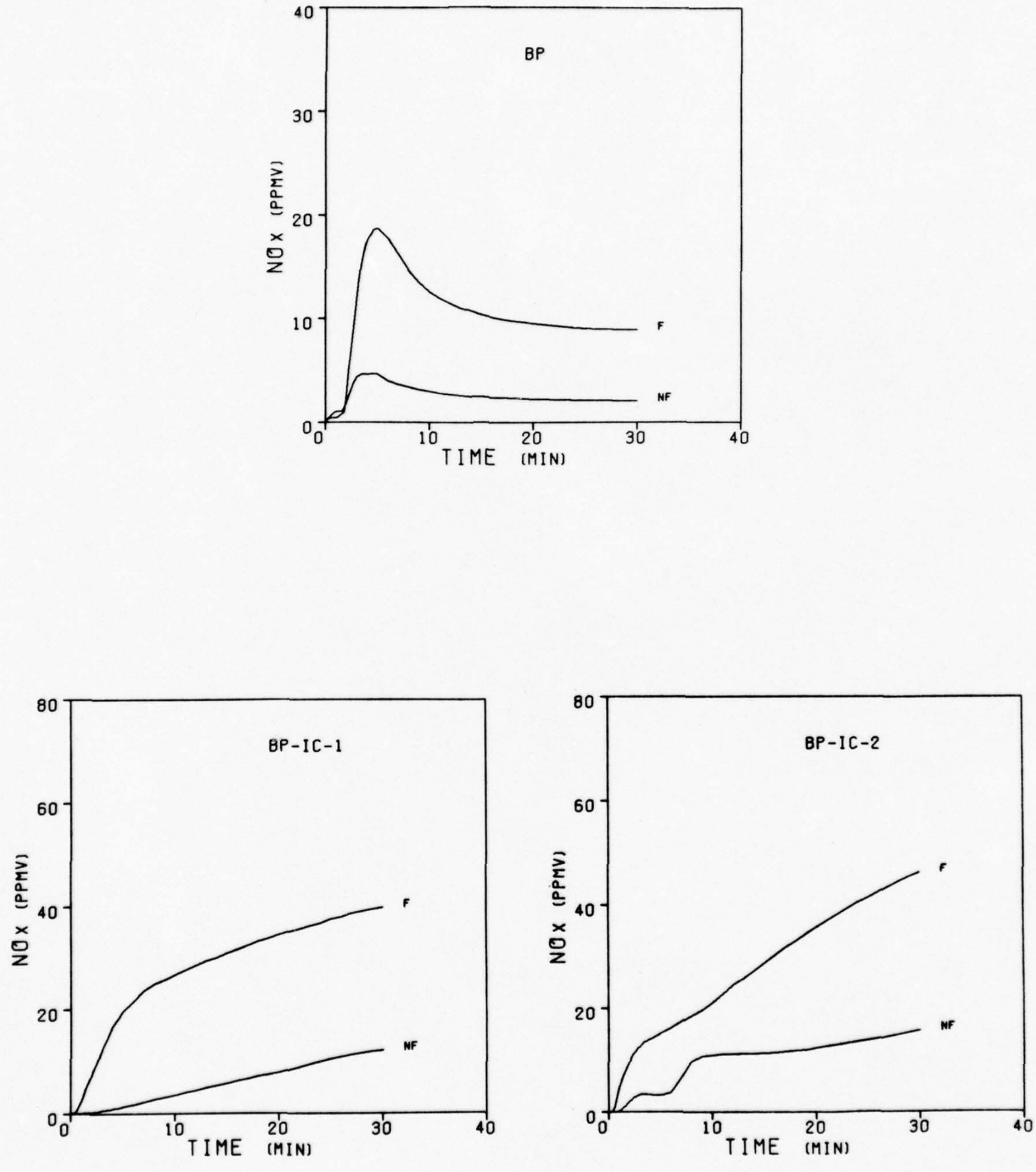


Figure 15. NO_x Concentrations During the Burning of BP-IC Compositions

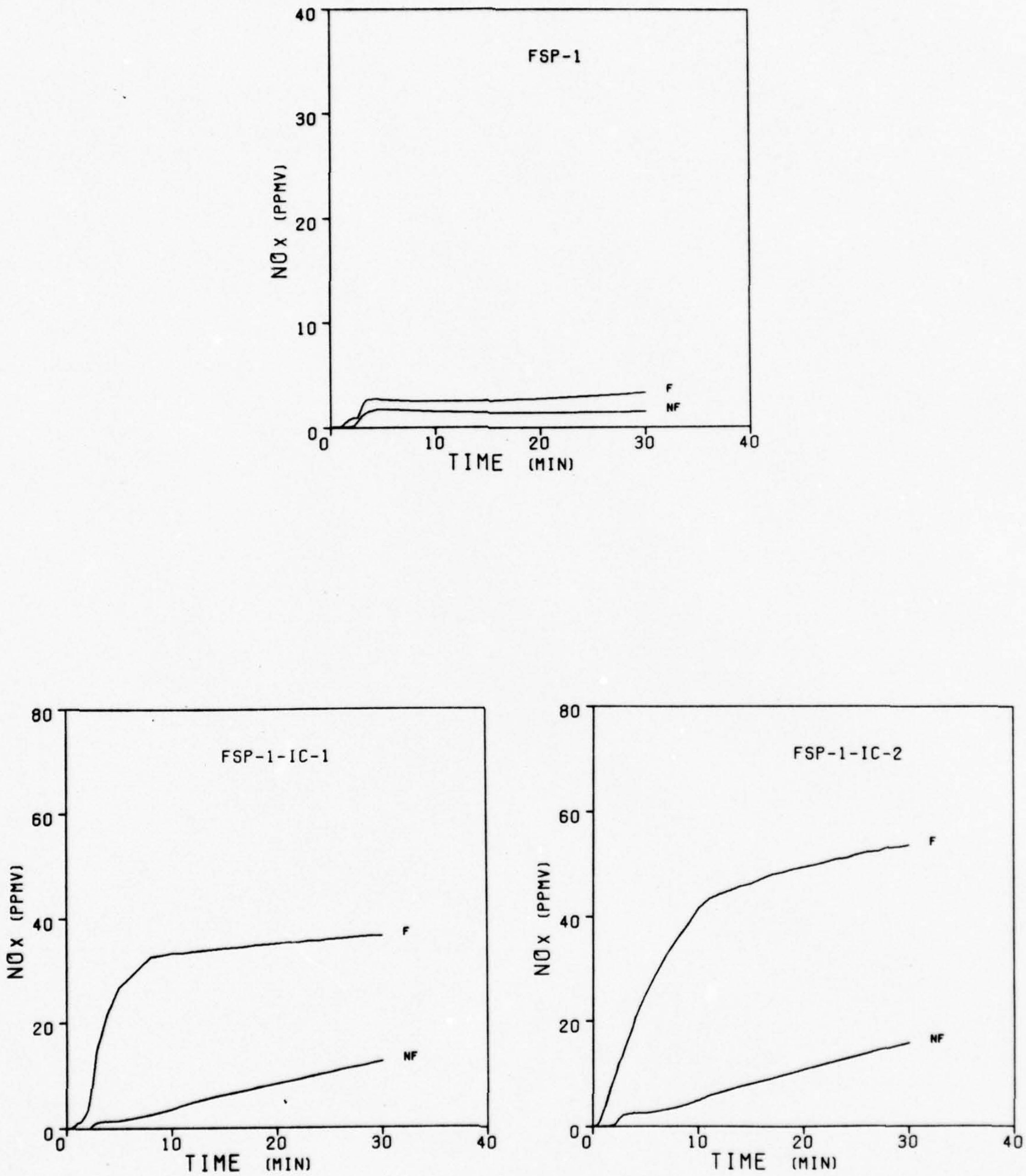
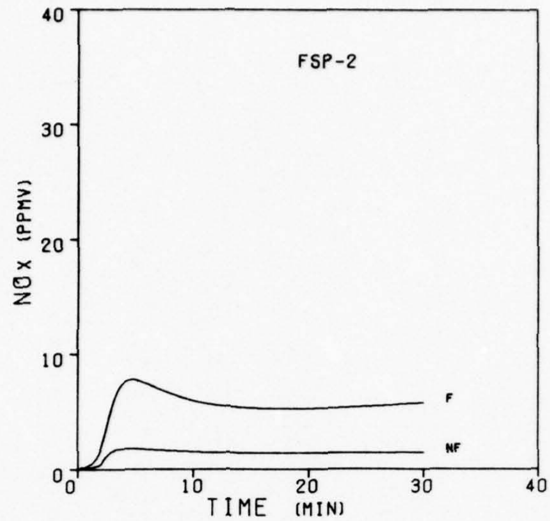
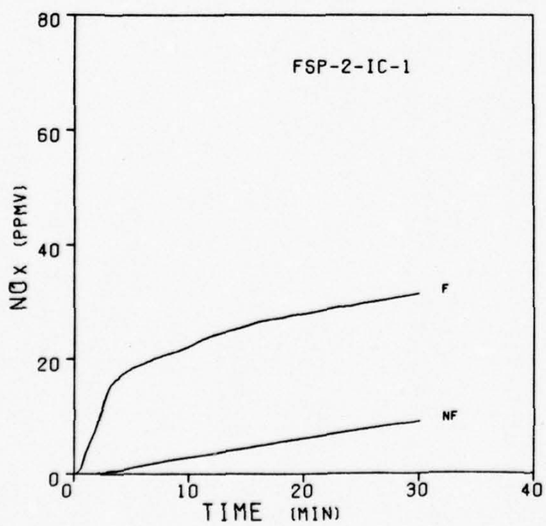


Figure 16. NO_x Concentrations During the Burning of FSP-1-IC Compositions





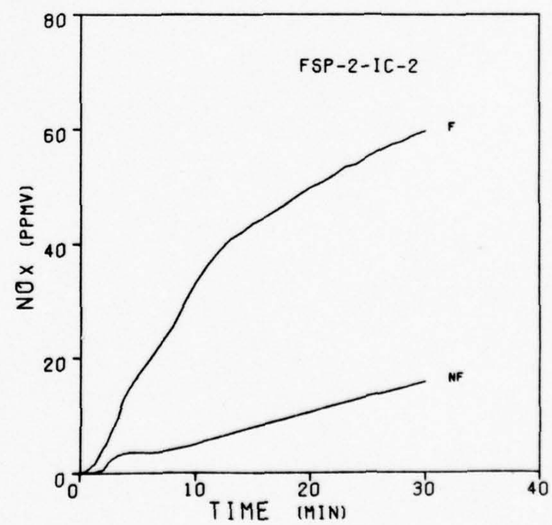
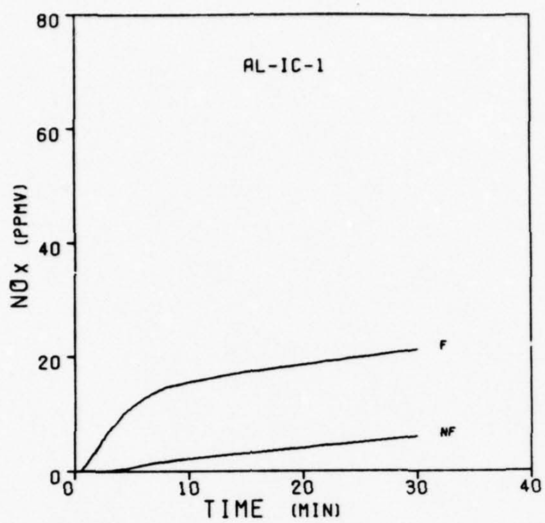


Figure 17. NO_x Concentrations During the Burning of FSP-2-IC Compositions



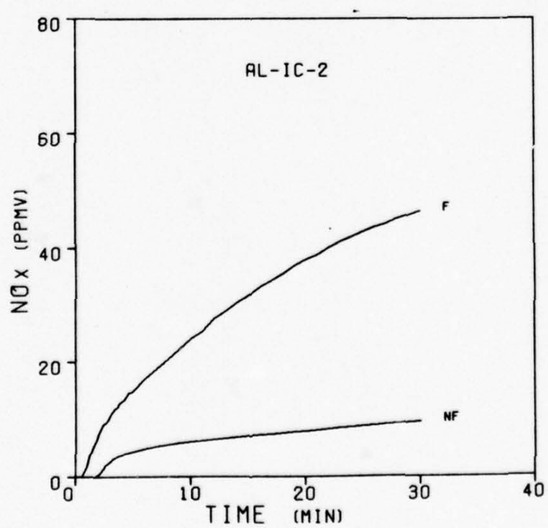


Figure 18. NO_x Concentrations during the Exposure of Al-IC Compositions

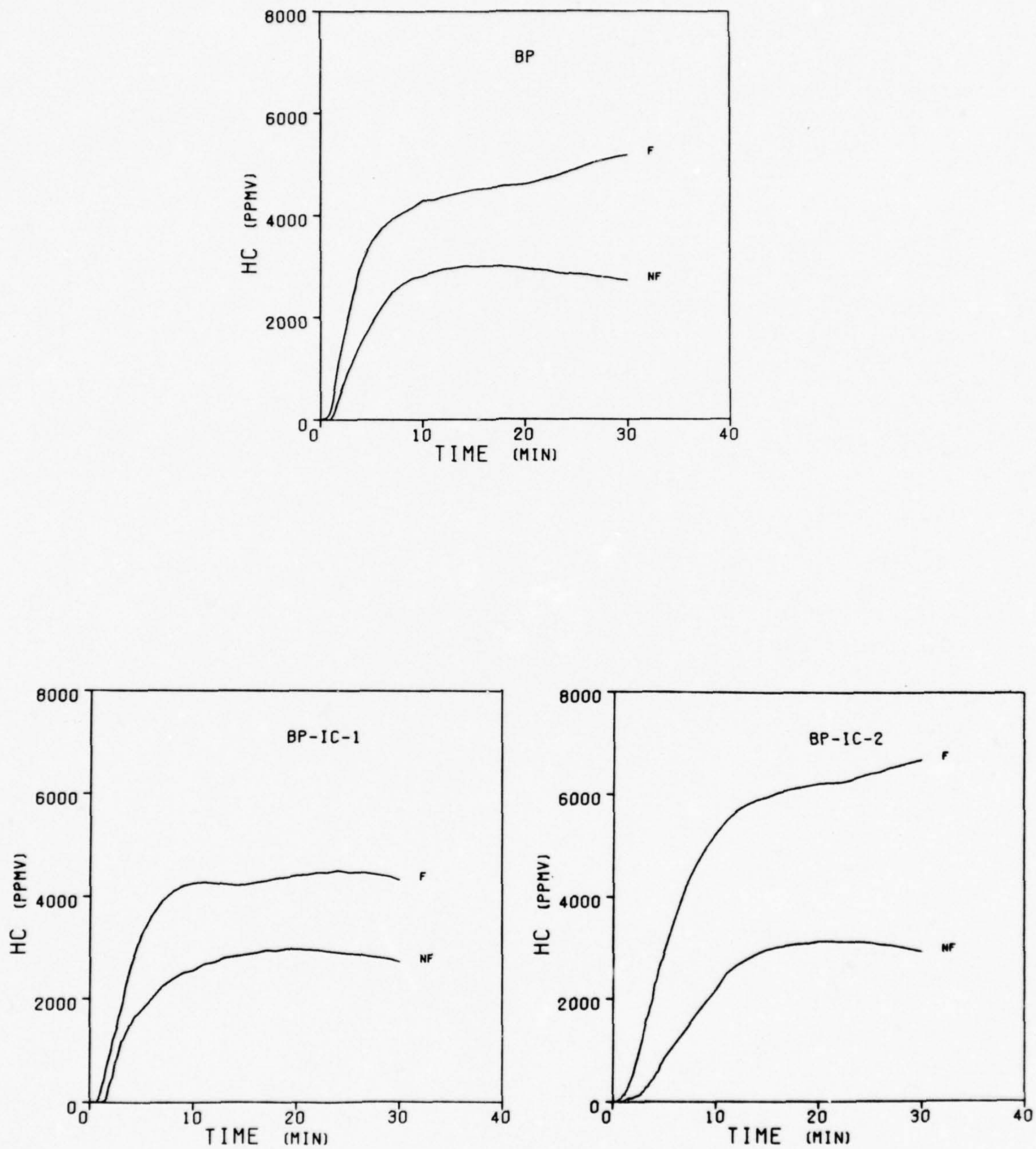


Figure 19. Hydrocarbons Concentrations During the Burning of BP Compositions

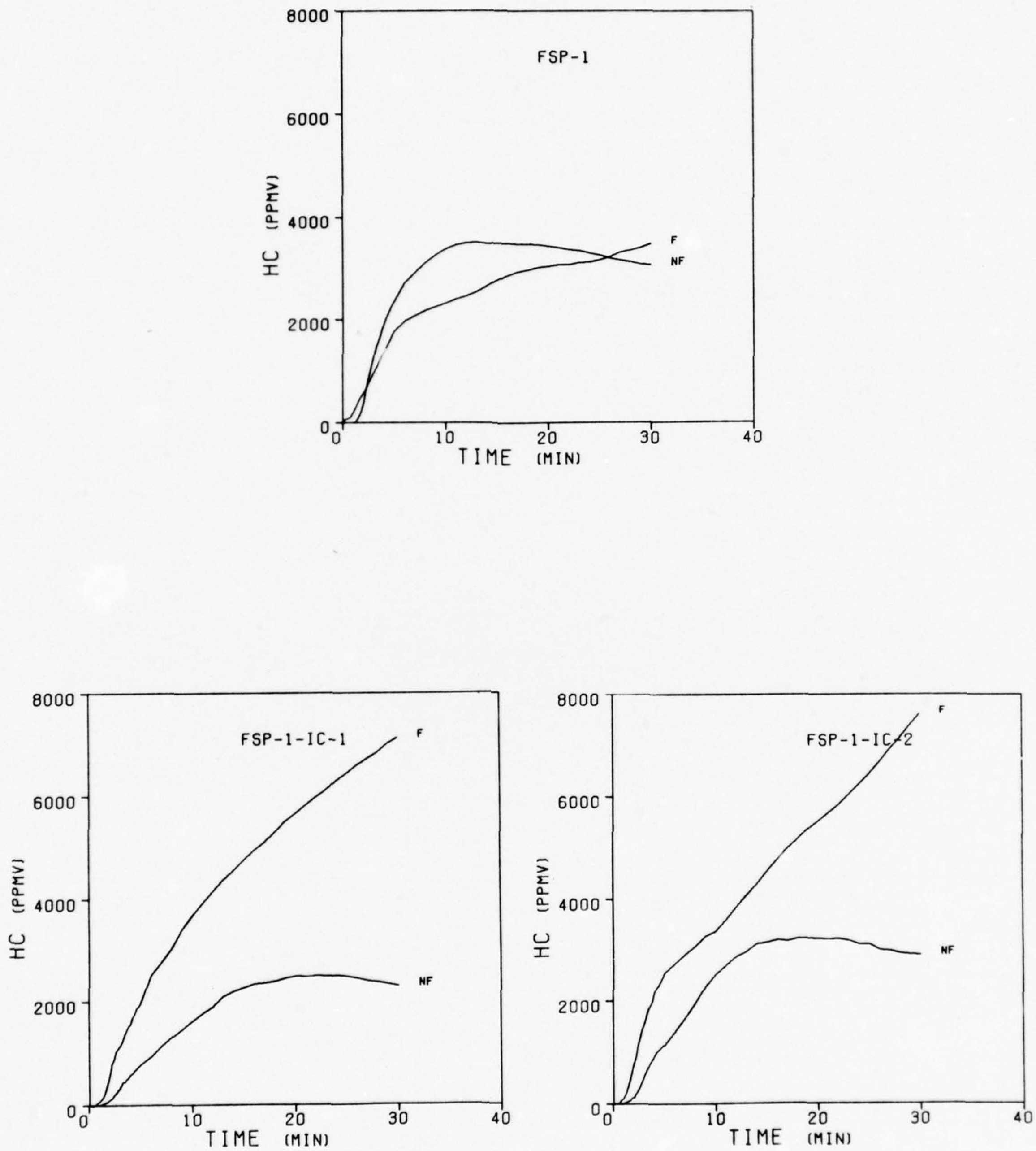


Figure 20. Hydrocarbons Concentrations During the Burning of FSP-1-IC Compositions

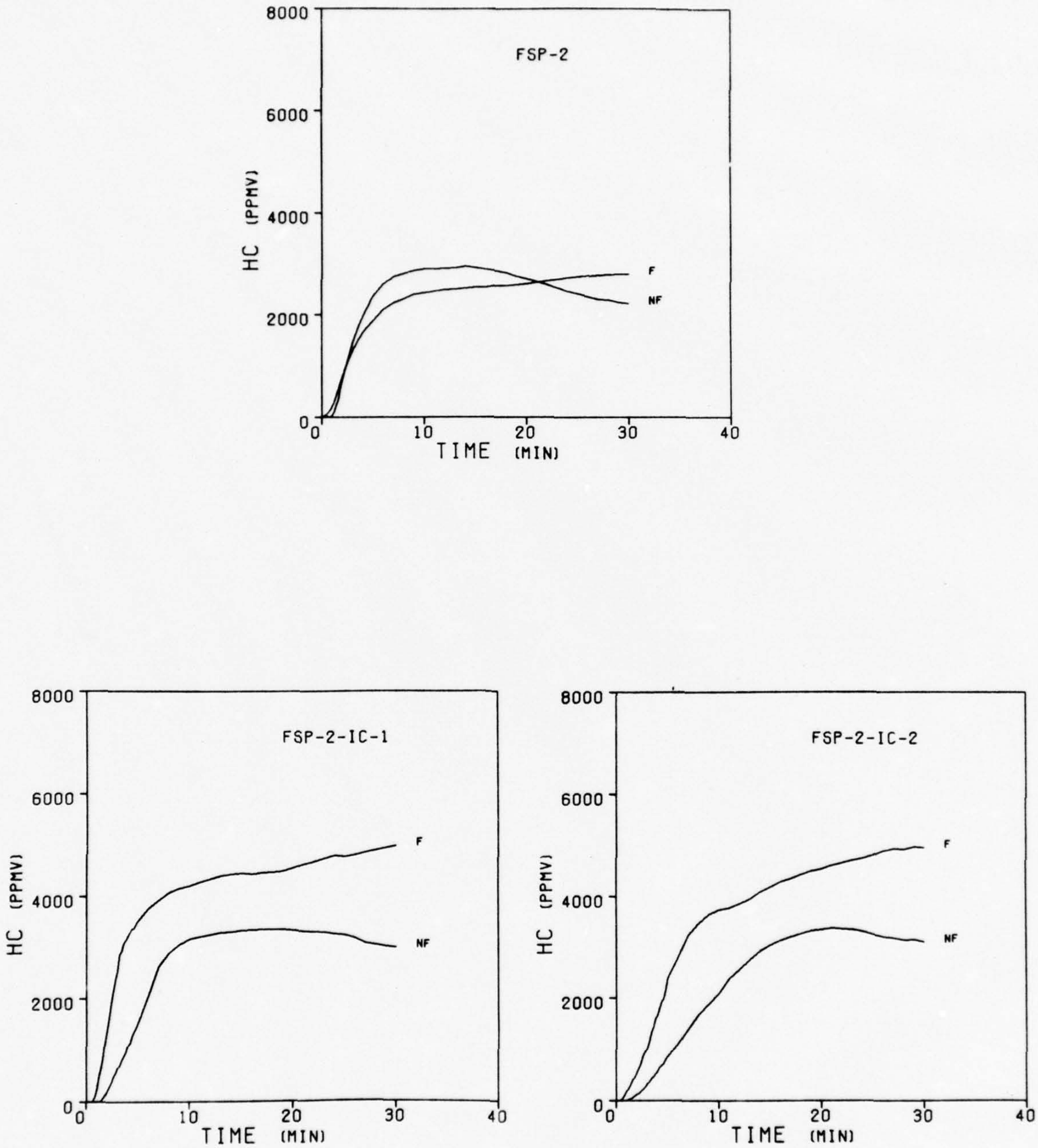
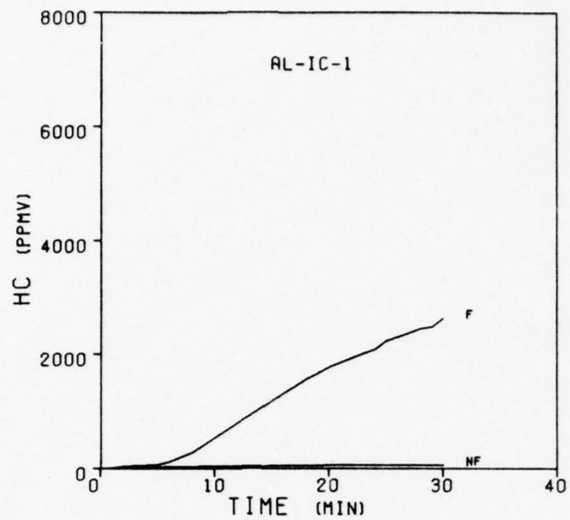


Figure 21. Hydrocarbons Concentrations During the Burning of FSP-2-IC Compositions



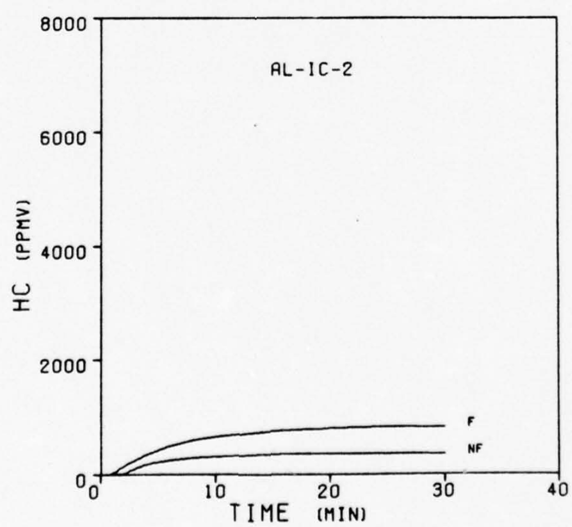


Figure 22. Hydrocarbons Concentrations During the Exposure of Al-IC Compositions

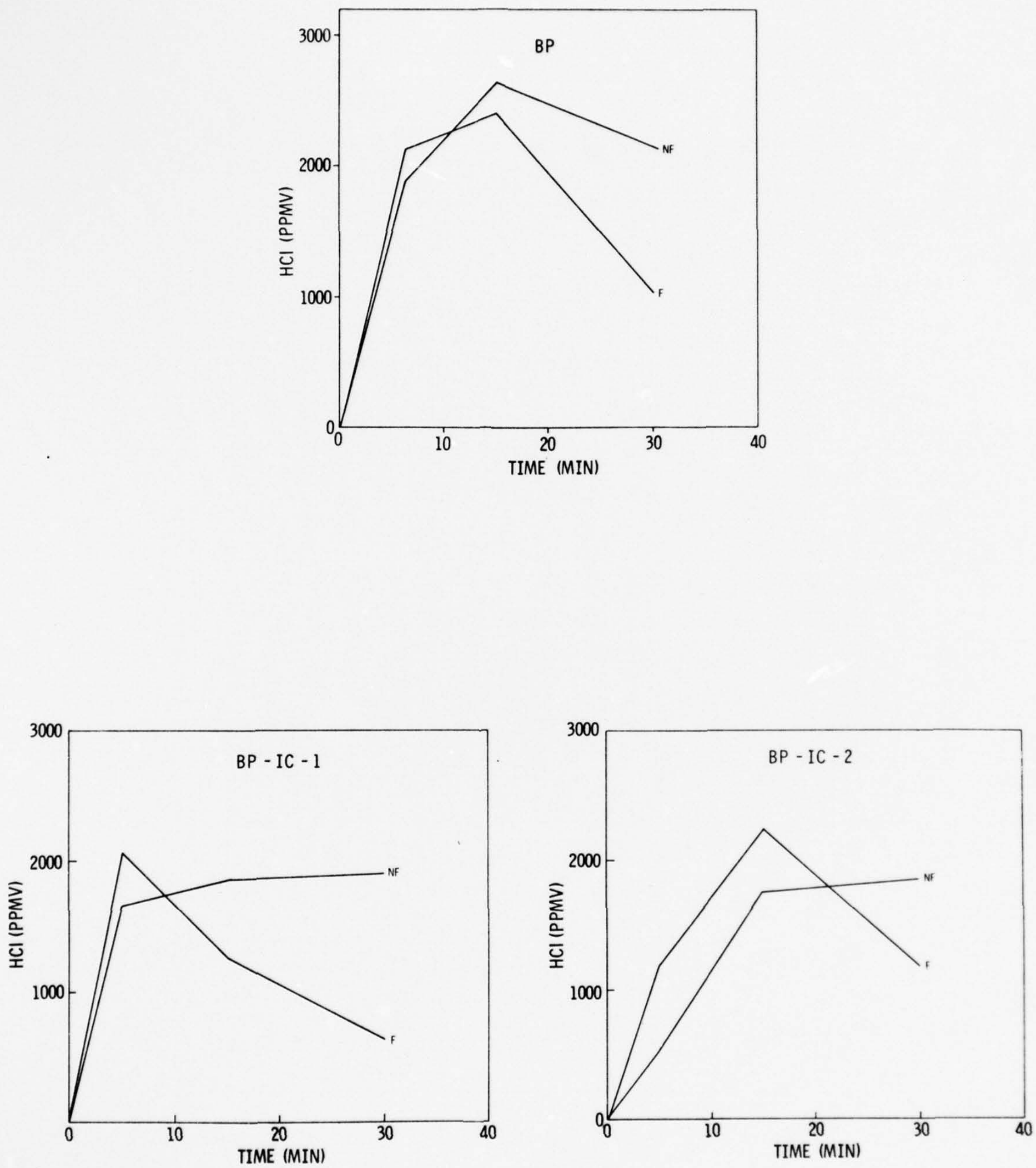


Figure 23. HCl Concentrations During the Burning of BP Compositions

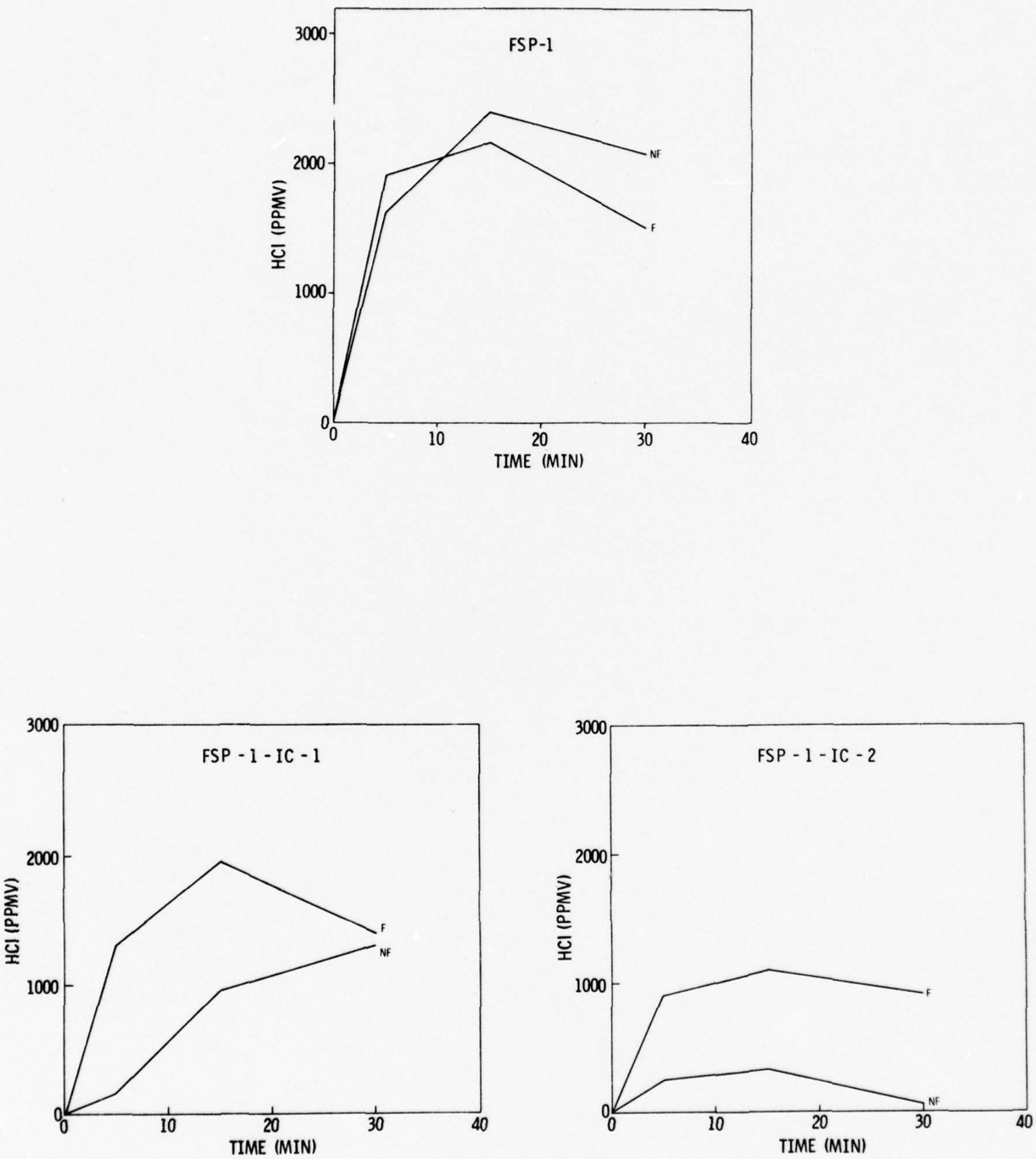


Figure 24. HCl Concentrations During the Burning of FSP-1-IC Compositions

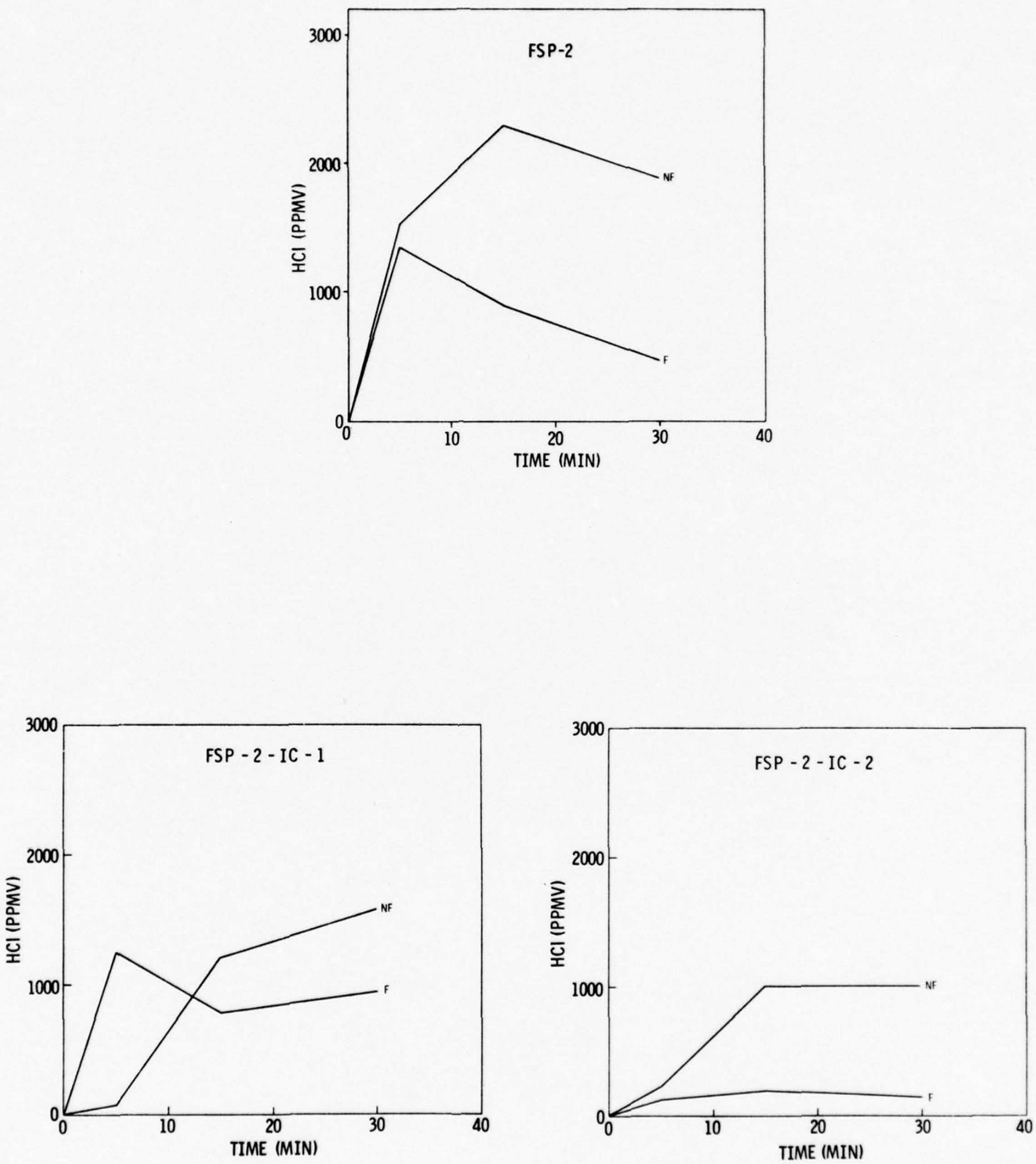


Figure 25. HCl Concentrations During the Burning of FSP-2-IC Compositions

Table VII

SAMPLE MASS DATA

Material	Sample Mass (g)[a]		Consumed Mass (g)[b]	
	Flame Exposure	Nonflame Exposure	Flame Exposure	Nonflame Exposure
BP-IC-1	11.58	12.82		7.26
BP-IC-2	12.55	12.82		
FSP-1-IC-1	17.56	16.98		5.95
FSP-1-IC-2	15.68	17.57		7.13
FSP-2-IC-1	13.24	15.43	6.63	6.00
FSP-2-IC-2	16.96	16.07	7.55	7.42
Al-IC-1	9.10	9.19		
Al-IC-2	8.50	8.44	1.51	0.86

[a] The dimensions of plastic specimens were 7.6 cm x 7.6 cm x 0.16 cm. The dimensions of the coated aluminum specimens were 7.6 cm x 7.6 cm x 0.066 cm.

[b] The chars formed from some specimens could not be recovered completely. Therefore, the data in the consumed mass column are incomplete.

Table VIII

COMBUSTION PRODUCTS FORMED FROM BP-IC-1 UNDER FLAME EXPOSURE CONDITIONS

MATERIAL PVC-BP-IC-1
SAMPLE MASS AVG 11.5759
IMPOSED EXPOSURE CONDITION FLAMING
FLUX 2.5 W/CM2, VERTICAL
DIMENSIONS 7.6 x 7.6 x.16

AVERAGE

TIME(MIN)	DS	CO(PPMV)	CO2(%)	HC(PPMV)	NOX(PPMV)	O2(%)
0.	0.	0.	0.00	0.	0.0	21.00
1.	66.	11.	0.04	149.	2.3	21.00
2.	204.	97.	0.13	968.	7.2	20.92
3.	277.	189.	0.23	1768.	12.3	20.71
4.	343.	266.	0.33	2668.	16.8	20.67
5.	399.	514.	0.43	3258.	19.7	20.44
6.	418.	646.	0.52	3631.	21.6	20.36
7.	424.	727.	0.60	3916.	23.7	20.22
8.	417.	786.	0.67	4105.	25.0	19.99
9.	399.	849.	0.74	4210.	25.8	19.94
10.	383.	907.	0.80	4263.	26.8	19.86
11.	363.	967.	0.87	4278.	27.7	19.75
12.	346.	1021.	0.94	4256.	28.6	19.64
13.	332.	1075.	1.00	4241.	29.5	19.52
14.	320.	1130.	1.06	4218.	30.1	19.35
15.	307.	1180.	1.12	4233.	31.0	19.31
16.	301.	1227.	1.19	4271.	31.7	19.26
17.	295.	1274.	1.26	4301.	32.5	19.14
18.	291.	1320.	1.32	4346.	33.3	19.00
19.	287.	1365.	1.39	4369.	33.9	18.88
20.	283.	1411.	1.46	4407.	34.6	18.72
21.	279.	1458.	1.54	4422.	35.2	18.62
22.	273.	1499.	1.60	4459.	35.7	18.52
23.	269.	1542.	1.67	4459.	36.3	18.40
24.	265.	1586.	1.74	4497.	36.8	18.29
25.	258.	1640.	1.82	4459.	37.6	18.20
26.	251.	1676.	1.88	4475.	38.0	18.05
27.	246.	1717.	1.95	4452.	38.7	17.93
28.	239.	1753.	2.02	4422.	39.1	17.78
29.	232.	1789.	2.09	4392.	39.5	17.71
30.	226.	1837.	2.16	4324.	39.8	17.59

Table IX

COMBUSTION PRODUCTS FORMED FROM BP-IC-1
UNDER NONFLAME EXPOSURE CONDITIONS

MATERIAL PVC-BP-IC-1
SAMPLE MASS AVG 12.8166
IMPOSED EXPOSURE CONDITION NONFLAMING
FLUX 2.5 W/CM2, VERTICAL
DIMENSIONS 7.6 x 7.6 x.16

AVERAGE

TIME(MIN)	DS	CO(PPMV)	CO2(%)	HC(PPMV)	NOX(PPMV)	O2(%)
0.	0.	0.	0.00	0.	0.0	21.00
1.	1.	4.	0.00	12.	0.1	20.87
2.	98.	4.	0.00	411.	0.3	20.70
3.	189.	4.	0.00	1181.	0.7	20.80
4.	225.	6.	0.00	1509.	1.0	20.66
5.	248.	13.	0.00	1794.	1.4	20.79
6.	260.	19.	0.00	2006.	1.8	20.68
7.	268.	27.	0.00	2245.	2.3	20.66
8.	272.	36.	0.00	2393.	2.8	20.62
9.	271.	45.	0.00	2511.	3.2	20.60
10.	271.	53.	0.00	2562.	3.6	20.55
11.	270.	65.	0.00	2679.	4.1	20.55
12.	268.	72.	0.00	2724.	4.5	20.44
13.	264.	87.	0.00	2801.	5.0	20.39
14.	259.	96.	0.00	2825.	5.4	20.32
15.	254.	102.	0.00	2864.	5.8	20.21
16.	249.	119.	0.00	2885.	6.3	20.29
17.	243.	128.	0.00	2940.	6.7	20.11
18.	238.	137.	0.00	2934.	7.2	20.17
19.	234.	144.	0.00	2965.	7.5	20.20
20.	229.	156.	0.00	2961.	7.9	20.20
21.	224.	161.	0.01	2947.	8.4	20.20
22.	220.	174.	0.01	2944.	8.9	20.19
23.	216.	182.	0.01	2911.	9.5	20.17
24.	211.	191.	0.01	2894.	10.0	20.16
25.	207.	199.	0.02	2872.	10.5	20.15
26.	202.	208.	0.02	2858.	10.9	20.14
27.	198.	215.	0.02	2816.	11.3	20.14
28.	194.	222.	0.03	2801.	11.6	20.13
29.	189.	224.	0.03	2768.	11.9	20.13
30.	185.	232.	0.03	2715.	12.1	20.13

Table X

COMBUSTION PRODUCTS FORMED FROM BP-IC-2

UNDER FLAME EXPOSURE CONDITIONS

MATERIAL PVC-BP-IC-2
SAMPLE MASS AVG 12.5466
IMPOSED EXPOSURE CONDITION FLAMING
FLUX 2.5 W/CM2, VERTICAL
DIMENSIONS 7.6 x 7.6 x.16

AVERAGE

TIME(MIN)	DS	CO(PPMV)	CO2(%)	HC(PPMV)	NOX(PPMV)	O2(%)
0.	0.	0.	0.00	0.	0.0	21.00
1.	29.	24.	0.00	136.	4.6	21.00
2.	167.	97.	0.10	567.	9.4	20.84
3.	236.	187.	0.18	1399.	12.6	20.70
4.	268.	266.	0.23	2283.	14.1	20.59
5.	284.	337.	0.27	2954.	15.2	20.51
6.	300.	411.	0.32	3589.	16.2	20.51
7.	316.	481.	0.38	4187.	17.4	20.45
8.	331.	548.	0.43	4611.	18.5	20.24
9.	346.	624.	0.48	4966.	19.6	20.21
10.	363.	699.	0.54	5245.	21.0	20.04
11.	379.	772.	0.60	5502.	22.7	20.00
12.	386.	845.	0.66	5690.	24.5	19.96
13.	383.	916.	0.71	5811.	25.7	19.79
14.	375.	988.	0.78	5902.	27.2	19.79
15.	367.	1054.	0.84	5962.	28.7	19.69
16.	358.	1126.	0.90	6038.	30.2	19.57
17.	350.	1198.	0.96	6098.	31.7	19.43
18.	340.	1261.	1.01	6136.	32.9	19.47
19.	333.	1332.	1.07	6181.	34.3	19.42
20.	325.	1390.	1.12	6219.	35.6	19.34
21.	318.	1453.	1.18	6226.	36.8	19.29
22.	311.	1515.	1.23	6241.	38.0	19.27
23.	304.	1575.	1.29	6279.	39.2	19.21
24.	298.	1634.	1.34	6355.	40.4	19.12
25.	291.	1689.	1.40	6407.	41.3	19.01
26.	285.	1770.	1.45	6453.	42.4	18.87
27.	279.	1819.	1.51	6528.	43.5	18.75
28.	274.	1887.	1.57	6581.	44.5	18.63
29.	268.	1942.	1.62	6641.	45.4	18.53
30.	263.	1993.	1.68	6694.	46.2	18.38

Table XI

COMBUSTION PRODUCTS FORMED FROM BP-IC-2

UNDER NONFLAME EXPOSURE CONDITIONS

MATERIAL PVC-BP-IC-2
SAMPLE MASS AVG 12.8162
IMPOSED EXPOSURE CONDITION NONFLAMING
FLUX 2.5 W/CM2, VERTICAL
DIMENSIONS 7.6 x 7.6 x.16

AVERAGE

TIME(MIN)	DS	CO(PPMV)	CO2(%)	HC(PPMV)	NOX(PPMV)	O2(%)
0.	0.	0.	0.00	0.	0.0	21.00
1.	6.	2.	0.00	10.	0.2	20.82
2.	32.	2.	0.00	90.	2.1	20.79
3.	58.	5.	0.00	220.	3.4	20.81
4.	150.	7.	0.00	472.	3.3	20.79
5.	193.	9.	0.00	858.	3.2	20.70
6.	209.	10.	0.00	1129.	3.8	20.68
7.	216.	14.	0.01	1392.	6.6	20.70
8.	222.	15.	0.01	1680.	9.8	20.77
9.	224.	19.	0.01	1942.	10.7	20.75
10.	227.	23.	0.01	2180.	10.9	20.79
11.	227.	35.	0.01	2495.	11.1	20.70
12.	227.	38.	0.02	2662.	11.1	20.85
13.	228.	45.	0.02	2782.	11.2	20.81
14.	227.	52.	0.02	2888.	11.2	20.89
15.	225.	60.	0.02	2971.	11.3	20.75
16.	226.	66.	0.02	3024.	11.4	20.74
17.	223.	72.	0.02	3046.	11.6	20.74
18.	220.	82.	0.03	3077.	11.8	20.68
19.	219.	87.	0.03	3092.	11.9	20.71
20.	216.	92.	0.03	3129.	12.3	20.73
21.	214.	100.	0.03	3129.	12.6	20.70
22.	212.	110.	0.03	3122.	12.9	20.65
23.	211.	121.	0.03	3122.	13.2	20.58
24.	209.	131.	0.03	3107.	13.5	20.50
25.	208.	142.	0.03	3099.	13.8	20.44
26.	207.	151.	0.04	3062.	14.1	20.40
27.	206.	159.	0.04	3046.	14.5	20.37
28.	204.	166.	0.04	3009.	14.9	20.36
29.	202.	173.	0.04	2971.	15.3	20.36
30.	201.	180.	0.04	2926.	15.7	20.36

Table XII

COMBUSTION PRODUCTS FORMED FROM FSP-1-IC-1

UNDER FLAME EXPOSURE CONDITIONS

MATERIAL FSP-1-IC-1
SAMPLE MASS AVG 17.5614
IMPOSED EXPOSURE CONDITION FLAMING
FLUX 2.5 W/CM2, VERTICAL
DIMENSIONS 7.6 x 7.6 x .16

AVERAGE

TIME(MIN)	DS	CO(PPMV)	CO2(%)	HC(PPMV)	NOX(PPMV)	O2(%)
0.	0.	0.	0.00	0.	0.0	21.00
1.	5.	6.	0.00	79.	1.1	20.80
2.	127.	42.	0.02	592.	3.4	20.64
3.	165.	162.	0.23	1147.	16.0	20.54
4.	185.	265.	0.39	1556.	22.6	20.33
5.	194.	362.	0.50	1969.	26.9	20.18
6.	199.	441.	0.57	2515.	28.8	20.03
7.	197.	538.	0.64	2775.	30.8	19.92
8.	195.	627.	0.71	3045.	32.7	19.80
9.	196.	705.	0.75	3406.	33.0	19.75
10.	198.	778.	0.79	3679.	33.4	19.60
11.	198.	860.	0.82	3919.	33.4	19.56
12.	197.	946.	0.86	4150.	33.7	19.49
13.	197.	1035.	0.90	4369.	33.9	19.47
14.	195.	1128.	0.93	4551.	34.1	19.43
15.	193.	1223.	0.96	4748.	34.3	19.27
16.	190.	1319.	0.99	4944.	34.4	19.29
17.	187.	1409.	1.02	5095.	34.6	19.19
18.	185.	1505.	1.05	5276.	34.9	19.14
19.	183.	1597.	1.08	5502.	35.0	19.08
20.	181.	1688.	1.11	5646.	35.2	19.13
21.	178.	1778.	1.14	5812.	35.4	19.06
22.	176.	1857.	1.17	5970.	35.4	18.97
23.	175.	1941.	1.20	6114.	35.7	18.88
24.	173.	2014.	1.23	6295.	35.7	18.96
25.	171.	2091.	1.26	6431.	36.0	18.86
26.	169.	2162.	1.29	6589.	36.1	18.84
27.	167.	2236.	1.32	6718.	36.3	18.84
28.	165.	2206.	1.35	6838.	36.5	18.69
29.	163.	2286.	1.38	7012.	36.6	18.66
30.	160.	2373.	1.40	7133.	36.6	18.62

Table XIII

COMBUSTION PRODUCTS FORMED FROM FSP-1-IC-1

UNDER NONFLAME EXPOSURE CONDITIONS

MATERIAL PVC-FSP-1-IC-1
SAMPLE MASS AVG 16.9847
IMPOSED EXPOSURE CONDITION NONFLAMING
FLUX 2.5 W/CM2, VERTICAL
DIMENSIONS 7.6 x 7.6 x.16

AVERAGE

TIME(MIN)	DS	CO(PPMV)	CO2(%)	HC(PPMV)	NOX(PPMV)	O2(%)
0.	0.	0.	0.00	0.	0.0	21.00
1.	1.	0.	0.00	10.	0.0	20.85
2.	20.	0.	0.01	111.	0.0	20.85
3.	68.	0.	0.01	354.	1.2	20.81
4.	125.	0.	0.02	589.	1.4	20.82
5.	159.	2.	0.03	794.	1.5	20.78
6.	172.	6.	0.04	937.	1.8	20.78
7.	180.	10.	0.05	1140.	2.2	20.89
8.	188.	13.	0.05	1308.	2.6	20.89
9.	193.	17.	0.06	1464.	3.1	20.84
10.	196.	21.	0.07	1616.	3.6	20.81
11.	198.	25.	0.08	1767.	4.3	20.81
12.	201.	30.	0.09	1896.	4.9	20.84
13.	202.	35.	0.09	2105.	5.4	20.85
14.	202.	40.	0.10	2201.	5.9	20.76
15.	203.	46.	0.11	2271.	6.3	20.85
16.	201.	55.	0.11	2345.	6.7	20.71
17.	199.	59.	0.12	2364.	7.1	20.81
18.	197.	66.	0.12	2389.	7.6	20.63
19.	194.	70.	0.13	2446.	8.0	20.61
20.	191.	76.	0.13	2485.	8.4	20.67
21.	189.	83.	0.13	2482.	8.8	20.73
22.	185.	89.	0.14	2499.	9.2	20.65
23.	183.	96.	0.14	2494.	9.7	20.70
24.	181.	105.	0.15	2499.	10.1	20.69
25.	178.	109.	0.15	2482.	10.5	20.66
26.	175.	115.	0.15	2435.	11.0	20.67
27.	173.	122.	0.16	2392.	11.4	20.70
28.	171.	120.	0.16	2367.	11.7	20.69
29.	168.	128.	0.16	2325.	12.2	20.73
30.	167.	134.	0.16	2286.	12.6	20.70

Table XIV

COMBUSTION PRODUCTS FORMED FROM FSP-1-IC-2

UNDER FLAME EXPOSURE CONDITIONS

MATERIAL PVC-FSP-1-IC-2
SAMPLE MASS AVG 15.6842
IMPOSED EXPOSURE CONDITION FLAMING
FLUX 2.5 W/CM2, VERTICAL
DIMENSIONS 7.6 x 7.6 x.16

AVERAGE

TIME(MIN)	DS	CO(PPMV)	CO2(%)	HC(PPMV)	NOX(PPMV)	O2(%)
0.	0.	0.	0.00	0.	0.0	21.00
1.	23.	13.	0.05	105.	3.0	21.00
2.	234.	85.	0.14	783.	9.2	21.00
3.	319.	173.	0.25	1537.	14.8	20.96
4.	359.	239.	0.36	2149.	20.6	20.75
5.	377.	324.	0.47	2551.	25.2	20.63
6.	377.	437.	0.57	2732.	29.1	20.39
7.	378.	565.	0.67	2915.	32.8	20.27
8.	369.	691.	0.76	3069.	35.8	20.13
9.	355.	788.	0.84	3271.	38.5	19.98
10.	342.	884.	0.94	3372.	41.6	19.80
11.	334.	979.	1.00	3594.	43.4	19.67
12.	322.	1048.	1.05	3840.	44.3	19.58
13.	312.	1109.	1.09	4072.	45.0	19.51
14.	301.	1160.	1.12	4284.	45.8	19.44
15.	291.	1209.	1.16	4533.	46.3	19.46
16.	283.	1256.	1.20	4759.	47.2	19.33
17.	275.	1305.	1.23	4978.	48.0	19.20
18.	270.	1355.	1.27	5159.	48.4	19.13
19.	266.	1406.	1.31	5363.	49.0	19.16
20.	263.	1456.	1.34	5514.	49.4	19.07
21.	263.	1511.	1.38	5673.	49.8	19.02
22.	262.	1567.	1.42	5831.	50.3	18.88
23.	262.	1629.	1.47	6027.	50.9	18.87
24.	260.	1688.	1.50	6231.	51.1	18.77
25.	260.	1750.	1.55	6435.	51.8	18.78
26.	258.	1809.	1.59	6661.	52.3	18.47
27.	257.	1869.	1.63	6910.	52.4	18.37
28.	254.	1928.	1.68	7129.	53.1	18.21
29.	253.	1983.	1.72	7378.	53.2	18.25
30.	249.	2040.	1.77	7612.	53.6	18.12

Table XV

COMBUSTION PRODUCTS FORMED FROM FSP-1-IC-2

UNDER NONFLAME EXPOSURE CONDITIONS

MATERIAL PVC-FSP-1-IC-2
SAMPLE MASS AVG 17.5677
IMPOSED EXPOSURE CONDITION NONFLAMING
FLUX 2.5 W/CM2, VERTICAL
DIMENSIONS 7.6 x 7.6 x.16

AVERAGE

TIME(MIN)	DS	CO(PPMV)	CO2(%)	HC(PPMV)	NOX(PPMV)	O2(%)
0.	0.	0.	0.00	0.	0.0	21.00
1.	1.	0.	0.00	11.	0.1	20.69
2.	20.	0.	0.00	131.	0.4	20.74
3.	89.	0.	0.02	544.	2.3	20.70
4.	177.	0.	0.03	932.	2.5	20.77
5.	230.	2.	0.04	1143.	2.6	20.65
6.	256.	7.	0.05	1393.	2.9	20.55
7.	266.	13.	0.06	1658.	3.3	20.66
8.	268.	21.	0.07	1951.	3.7	20.76
9.	269.	28.	0.09	2283.	4.3	20.72
10.	268.	35.	0.10	2519.	5.0	20.67
11.	268.	43.	0.11	2702.	5.9	20.62
12.	267.	50.	0.13	2865.	6.5	20.58
13.	269.	57.	0.14	2974.	7.1	20.55
14.	274.	66.	0.15	3120.	7.7	20.44
15.	273.	75.	0.15	3153.	8.2	20.39
16.	274.	86.	0.16	3202.	8.7	20.42
17.	272.	96.	0.16	3179.	9.2	20.42
18.	271.	106.	0.17	3233.	9.8	20.47
19.	269.	116.	0.17	3227.	10.3	20.50
20.	265.	126.	0.18	3224.	10.9	20.50
21.	264.	135.	0.18	3208.	11.4	20.47
22.	263.	144.	0.19	3220.	11.9	20.46
23.	261.	153.	0.19	3178.	12.4	20.43
24.	257.	161.	0.20	3114.	12.9	20.53
25.	256.	170.	0.20	3105.	13.4	20.54
26.	253.	179.	0.20	3003.	13.9	20.53
27.	250.	187.	0.21	2980.	14.5	20.46
28.	249.	195.	0.21	2929.	14.9	20.53
29.	247.	203.	0.22	2913.	15.4	20.53
30.	245.	210.	0.22	2898.	15.9	20.58

Table XVI

COMBUSTION PRODUCTS FORMED FROM FSP-2-IC-1

UNDER FLAME EXPOSURE CONDITIONS

MATERIAL PVC-FSP-2-IC-1
SAMPLE MASS AVG 13.2391
IMPOSED EXPOSURE CONDITION FLAMING
FLUX 2.5 W/CM2, VERTICAL
DIMENSIONS 7.6 x 7.6 x .16

AVERAGE

TIME(MIN)	DS	CO(PPMV)	CO2(%)	HC(PPMV)	NOX(PPMV)	O2(%)
0.	0.	0.	0.00	0.	0.0	21.00
1.	53.	36.	0.05	244.	3.7	20.99
2.	130.	126.	0.19	1377.	8.6	20.81
3.	187.	249.	0.36	2539.	14.8	20.67
4.	221.	328.	0.49	3206.	17.1	20.52
5.	239.	379.	0.58	3518.	18.4	20.40
6.	247.	438.	0.68	3755.	19.2	20.26
7.	242.	522.	0.77	3921.	20.1	20.08
8.	230.	601.	0.84	4069.	20.8	20.00
9.	217.	678.	0.93	4149.	21.4	19.85
10.	204.	754.	1.00	4198.	22.2	19.70
11.	192.	825.	1.07	4266.	23.3	19.59
12.	184.	893.	1.14	4333.	24.1	19.41
13.	176.	955.	1.20	4386.	24.7	19.41
14.	168.	1019.	1.28	4416.	25.2	19.25
15.	161.	1081.	1.35	4439.	25.8	19.11
16.	154.	1141.	1.43	4416.	26.5	19.00
17.	149.	1190.	1.49	4447.	26.9	19.03
18.	145.	1228.	1.55	4462.	27.2	18.82
19.	141.	1264.	1.61	4484.	27.7	18.67
20.	137.	1297.	1.67	4537.	27.9	18.63
21.	135.	1331.	1.73	4605.	28.3	18.60
22.	132.	1363.	1.78	4658.	28.7	18.47
23.	128.	1395.	1.84	4718.	29.1	18.41
24.	125.	1425.	1.90	4779.	29.2	18.34
25.	122.	1455.	1.97	4764.	29.7	18.16
26.	119.	1483.	2.03	4804.	30.0	18.08
27.	116.	1513.	2.10	4845.	30.3	17.97
28.	113.	1544.	2.17	4886.	30.7	17.87
29.	111.	1575.	2.24	4928.	31.0	17.76
30.	108.	1608.	2.32	4970.	31.4	17.65

Table XVII

COMBUSTION PRODUCTS FORMED FROM FSP-2-IC-1 UNDER NONFLAME EXPOSURE CONDITIONS

MATERIAL PVC-FSP-2-IC-1
SAMPLE MASS AVG 15.4281
IMPOSED EXPOSURE CONDITION NONFLAMING
FLUX 2.5 W/CM2, VERTICAL
DIMENSIONS 7.6 X 7.6 X.16

AVERAGE

TIME(MIN)	DS	CO(PPMV)	CO2(%)	HC(PPMV)	NOX(PPMV)	O2(%)
0.	0.	0.	0.00	0.	0.0	21.00
1.	1.	0.	0.01	0.	0.0	20.84
2.	44.	0.	0.01	210.	0.1	20.82
3.	84.	0.	0.02	662.	0.4	20.84
4.	109.	0.	0.04	1077.	0.6	20.73
5.	131.	2.	0.05	1528.	1.1	20.63
6.	147.	7.	0.06	2059.	1.5	20.67
7.	160.	13.	0.08	2633.	1.9	20.70
8.	168.	20.	0.09	2888.	2.3	20.71
9.	174.	28.	0.10	3053.	2.6	20.63
10.	179.	36.	0.11	3155.	2.9	20.51
11.	181.	45.	0.12	3204.	3.2	20.35
12.	182.	55.	0.12	3237.	3.5	20.37
13.	179.	64.	0.12	3279.	3.9	20.52
14.	176.	76.	0.13	3290.	4.2	20.58
15.	174.	87.	0.13	3315.	4.5	20.52
16.	170.	98.	0.14	3335.	4.9	20.54
17.	165.	109.	0.14	3342.	5.2	20.51
18.	161.	120.	0.15	3339.	5.6	20.47
19.	157.	131.	0.15	3344.	5.9	20.52
20.	153.	141.	0.16	3320.	6.2	20.52
21.	148.	152.	0.16	3305.	6.5	20.55
22.	145.	162.	0.16	3285.	6.8	20.51
23.	141.	172.	0.17	3282.	7.1	20.52
24.	138.	182.	0.17	3249.	7.4	20.50
25.	136.	192.	0.18	3226.	7.7	20.40
26.	133.	202.	0.18	3172.	8.0	20.43
27.	130.	212.	0.19	3072.	8.3	20.29
28.	128.	214.	0.19	3038.	8.6	20.33
29.	125.	225.	0.20	2997.	8.8	20.25
30.	123.	236.	0.20	2982.	9.1	20.29

Table XVIII

COMBUSTION PRODUCTS FORMED FROM FSP-2-IC-2

UNDER FLAME EXPOSURE CONDITIONS

MATERIAL PVC-FSP-2-IC-2
SAMPLE MASS AVG 16.9573
IMPOSED EXPOSURE CONDITION FLAMING
FLUX 2.5 W/CM2, VERTICAL
DIMENSIONS 7.6 x 7.6 x .16

AVERAGE

TIME(MIN)	DS	CO(PPMV)	CO2(%)	HC(PPMV)	NOX(PPMV)	O2(%)
0.	0.	0.	0.00	0.	0.0	21.00
1.	11.	6.	0.02	189.	1.3	21.00
2.	77.	43.	0.06	543.	4.4	20.95
3.	169.	97.	0.14	1006.	8.7	20.92
4.	335.	139.	0.24	1663.	13.8	20.86
5.	381.	185.	0.34	2393.	17.1	20.77
6.	394.	240.	0.42	2800.	19.8	20.59
7.	398.	302.	0.50	3238.	22.7	20.58
8.	407.	384.	0.59	3472.	25.5	20.40
9.	416.	482.	0.69	3653.	29.6	20.09
10.	410.	586.	0.78	3736.	33.2	20.08
11.	398.	657.	0.86	3781.	36.2	19.86
12.	383.	720.	0.93	3857.	38.7	19.81
13.	373.	780.	0.99	3947.	40.8	19.70
14.	365.	856.	1.03	4091.	42.0	19.51
15.	356.	934.	1.08	4189.	43.6	19.41
16.	347.	1016.	1.12	4287.	44.6	19.44
17.	338.	1096.	1.17	4347.	45.8	19.21
18.	330.	1172.	1.21	4430.	47.1	19.18
19.	323.	1243.	1.26	4498.	48.5	19.17
20.	317.	1315.	1.31	4544.	49.8	19.05
21.	313.	1381.	1.35	4611.	50.7	19.05
22.	309.	1444.	1.40	4657.	51.9	19.02
23.	303.	1510.	1.45	4710.	53.4	18.88
24.	299.	1576.	1.50	4747.	53.9	18.83
25.	294.	1640.	1.55	4808.	55.2	18.86
26.	289.	1704.	1.60	4891.	56.3	18.73
27.	286.	1768.	1.64	4928.	57.3	18.65
28.	282.	1832.	1.68	4921.	57.9	18.57
29.	277.	1893.	1.73	4966.	59.0	18.34
30.	273.	1958.	1.78	4951.	59.7	18.29

Table XIX

COMBUSTION PRODUCTS FORMED FROM FSP-2-IC-2

UNDER NONFLAME EXPOSURE CONDITIONS

MATERIAL PVC-FSP-2-IC-2
SAMPLE MASS AVG 16.0654
IMPOSED EXPOSURE CONDITION NONFLAMING
FLUX 2.5 W/CM2, VERTICAL
DIMENSIONS 7.6 x 7.6 x .16

AVERAGE

TIME(MIN)	DS	CO(PPMV)	CO2(%)	HC(PPMV)	NOX(PPMV)	O2(%)
0.	0.	0.	0.00	0.	0.0	21.00
1.	4.	0.	0.00	12.	0.1	20.78
2.	30.	0.	0.01	131.	0.7	20.82
3.	54.	0.	0.02	329.	2.8	20.94
4.	94.	0.	0.02	567.	3.5	20.88
5.	153.	0.	0.04	863.	3.6	20.75
6.	223.	2.	0.05	1108.	3.5	20.81
7.	247.	9.	0.06	1399.	3.7	20.89
8.	260.	17.	0.07	1678.	4.1	20.83
9.	267.	25.	0.08	1867.	4.5	20.85
10.	269.	32.	0.09	2103.	5.0	20.86
11.	267.	38.	0.10	2390.	5.7	20.83
12.	267.	46.	0.11	2569.	6.2	20.92
13.	266.	53.	0.12	2759.	6.8	20.82
14.	263.	62.	0.14	2927.	7.4	20.88
15.	261.	71.	0.15	3049.	8.0	20.70
16.	257.	79.	0.15	3144.	8.5	20.68
17.	252.	88.	0.16	3206.	9.0	20.70
18.	249.	98.	0.16	3271.	9.5	20.72
19.	247.	107.	0.17	3328.	10.1	20.64
20.	244.	115.	0.18	3350.	10.6	20.63
21.	241.	125.	0.18	3378.	11.2	20.63
22.	238.	133.	0.19	3363.	11.7	20.62
23.	235.	142.	0.19	3354.	12.2	20.59
24.	233.	150.	0.20	3315.	12.7	20.57
25.	230.	159.	0.20	3251.	13.3	20.55
26.	228.	167.	0.20	3205.	13.7	20.53
27.	225.	176.	0.21	3179.	14.2	20.52
28.	224.	184.	0.21	3135.	14.7	20.52
29.	221.	191.	0.21	3147.	15.3	20.52
30.	219.	199.	0.22	3097.	15.8	20.52

Table XX

COMBUSTION PRODUCTS FORMED FROM Al-IC-1
UNDER FLAME EXPOSURE CONDITIONS

MATERIAL AL-IC-1
SAMPLE MASS AVG 9.1019
IMPOSED EXPOSURE CONDITION FLAMING
FLUX 2.5 W/CM2, VERTICAL
DIMENSIONS 7.6 X 7.6

AVERAGE

TIME(MIN)	DS	CO(PPMV)	CO2(%)	HC(PPMV)	NOX(PPMV)	O2(%)
0.	0.	0.	0.00	0.	0.0	21.00
1.	2.	5.	0.03	10.	1.2	20.99
2.	12.	34.	0.08	35.	4.1	20.95
3.	20.	55.	0.12	48.	7.1	20.82
4.	27.	73.	0.18	55.	9.4	20.73
5.	33.	91.	0.23	66.	11.3	20.70
6.	39.	111.	0.29	124.	12.7	20.59
7.	45.	126.	0.33	197.	13.8	20.49
8.	50.	145.	0.38	284.	14.7	20.55
9.	55.	162.	0.41	413.	15.1	20.44
10.	59.	183.	0.44	536.	15.6	20.37
11.	63.	208.	0.47	667.	15.9	20.38
12.	67.	233.	0.50	804.	16.3	20.23
13.	71.	262.	0.54	923.	16.7	20.33
14.	74.	292.	0.57	1049.	17.0	20.22
15.	77.	321.	0.60	1181.	17.4	20.08
16.	79.	358.	0.63	1308.	17.5	20.17
17.	81.	393.	0.66	1433.	17.8	20.08
18.	84.	433.	0.69	1565.	18.1	20.06
19.	85.	489.	0.72	1663.	18.3	19.95
20.	87.	554.	0.75	1766.	18.6	19.87
21.	89.	638.	0.78	1849.	18.8	19.88
22.	91.	730.	0.81	1931.	19.2	19.88
23.	92.	819.	0.84	2007.	19.3	19.78
24.	94.	908.	0.87	2079.	19.7	19.70
25.	95.	1004.	0.90	2234.	19.9	19.56
26.	96.	1105.	0.94	2302.	20.1	19.54
27.	97.	1200.	0.96	2368.	20.4	19.51
28.	98.	1278.	0.99	2446.	20.7	19.37
29.	99.	1356.	1.02	2477.	20.9	19.51
30.	100.	1405.	1.05	2634.	21.2	19.44

Table XXI

COMBUSTION PRODUCTS FORMED FROM Al-IC-1 UNDER NONFLAME EXPOSURE CONDITIONS

MATERIAL AL-IC-1
SAMPLE MASS AVG 9.1910
IMPOSED EXPOSURE CONDITION NONFLAMING
FLUX 2.5 W/CM2. VERTICAL
DIMENSIONS 7.6 x 7.6

AVERAGE

TIME(MIN)	DS	CO(PPMV)	CO2(%)	HC(PPMV)	NOX(PPMV)	O2(%)
0.	0.	0.	0.00	0.	0.0	21.00
1.	0.	0.	0.00	0.	0.0	21.00
2.	6.	0.	0.00	0.	0.0	20.87
3.	18.	0.	0.01	9.	0.1	20.92
4.	26.	0.	0.01	18.	0.4	20.94
5.	30.	0.	0.01	22.	0.7	20.82
6.	34.	0.	0.01	26.	1.1	20.80
7.	38.	0.	0.01	30.	1.5	20.85
8.	42.	0.	0.01	34.	1.7	20.85
9.	45.	0.	0.01	36.	2.0	20.86
10.	48.	1.	0.02	39.	2.2	20.92
11.	51.	2.	0.02	40.	2.4	20.94
12.	54.	3.	0.02	42.	2.6	20.93
13.	56.	4.	0.02	43.	2.8	20.92
14.	58.	5.	0.02	41.	3.0	20.98
15.	60.	6.	0.02	46.	3.1	20.93
16.	62.	7.	0.02	49.	3.3	20.80
17.	64.	9.	0.02	51.	3.5	20.86
18.	66.	10.	0.02	53.	3.7	20.94
19.	67.	11.	0.02	54.	3.9	20.87
20.	68.	12.	0.02	55.	4.0	20.98
21.	70.	14.	0.03	56.	4.3	21.00
22.	71.	15.	0.03	56.	4.5	21.00
23.	72.	16.	0.03	57.	4.6	21.00
24.	73.	18.	0.03	59.	4.8	20.93
25.	74.	19.	0.03	60.	5.0	20.86
26.	74.	20.	0.03	60.	5.2	20.81
27.	74.	22.	0.03	61.	5.4	20.80
28.	75.	22.	0.03	62.	5.6	20.80
29.	75.	24.	0.03	62.	5.8	20.82
30.	76.	25.	0.03	62.	6.0	20.84

Table XXII

COMBUSTION PRODUCTS FORMED FROM Al-IC-2
UNDER FLAME EXPOSURE CONDITIONS

MATERIAL AL-IC-2
SAMPLE MASS AVG 8.4956
IMPOSED EXPOSURE CONDITION FLAMING
FLUX 2.5 W/CM2, VERTICAL
DIMENSIONS 7.6 X 7.6

AVERAGE

TIME(MIN)	DS	CO(PPMV)	CO2(%)	HC(PPMV)	NOX(PPMV)	O2(%)
0.	0.	0.	0.00	0.	0.0	21.00
1.	21.	6.	0.03	31.	1.8	20.80
2.	91.	46.	0.08	154.	7.6	20.77
3.	132.	69.	0.12	261.	10.7	20.62
4.	162.	86.	0.18	355.	13.1	20.47
5.	177.	103.	0.22	429.	15.0	20.51
6.	185.	121.	0.27	496.	17.1	20.55
7.	188.	138.	0.31	551.	18.8	20.40
8.	187.	155.	0.36	595.	20.5	20.31
9.	185.	172.	0.40	631.	22.3	20.38
10.	181.	187.	0.45	661.	24.1	20.23
11.	177.	203.	0.49	681.	25.4	20.31
12.	172.	212.	0.53	705.	27.6	20.27
13.	167.	229.	0.58	723.	28.9	20.09
14.	163.	247.	0.62	740.	30.4	20.04
15.	158.	263.	0.66	761.	31.7	20.00
16.	154.	280.	0.70	768.	33.2	19.90
17.	150.	297.	0.74	779.	34.3	19.81
18.	146.	315.	0.78	786.	35.5	19.65
19.	143.	333.	0.82	795.	36.9	19.54
20.	140.	351.	0.86	805.	38.0	19.62
21.	138.	370.	0.90	814.	38.8	19.71
22.	135.	389.	0.95	819.	40.1	19.65
23.	133.	407.	0.98	825.	41.1	19.71
24.	130.	425.	1.02	827.	41.9	19.67
25.	129.	441.	1.06	828.	42.8	19.56
26.	126.	458.	1.09	827.	43.6	19.40
27.	125.	473.	1.13	826.	44.2	19.35
28.	123.	488.	1.16	822.	45.1	19.25
29.	121.	503.	1.20	820.	45.7	19.18
30.	119.	518.	1.24	817.	46.4	19.11

Table XXIII

COMBUSTION PRODUCTS FORMED FROM Al-IC-2 UNDER NONFLAME EXPOSURE CONDITIONS

MATERIAL AL-IC-2
SAMPLE MASS AVG 8.4462
IMPOSED EXPOSURE CONDITION NONFLAMING
FLUX 2.5 W/CM2, VERTICAL
DIMENSIONS 7.6 X 7.6

AVERAGE

TIME(MIN)	DS	CO(PPMV)	CO2(%)	HC(PPMV)	NOX(PPMV)	O2(%)
0.	0.	0.	0.00	0.	0.0	21.00
1.	0.	0.	0.00	0.	0.0	20.78
2.	10.	0.	0.00	16.	0.4	20.69
3.	30.	0.	0.01	113.	2.6	20.75
4.	41.	1.	0.01	176.	3.8	20.73
5.	51.	3.	0.01	218.	4.4	20.60
6.	60.	3.	0.01	251.	4.9	20.62
7.	68.	4.	0.01	272.	5.3	20.69
8.	75.	5.	0.02	288.	5.6	20.65
9.	80.	5.	0.02	302.	5.9	20.67
10.	84.	6.	0.02	313.	6.1	20.56
11.	88.	7.	0.02	325.	6.3	20.33
12.	90.	8.	0.02	330.	6.5	20.45
13.	93.	9.	0.03	339.	6.7	20.40
14.	94.	10.	0.03	346.	6.9	20.43
15.	96.	10.	0.03	351.	7.1	20.40
16.	96.	10.	0.03	355.	7.3	20.45
17.	97.	11.	0.03	359.	7.4	20.47
18.	97.	11.	0.03	360.	7.6	20.33
19.	97.	12.	0.03	361.	7.8	20.37
20.	97.	13.	0.03	363.	7.9	20.32
21.	97.	14.	0.03	363.	8.1	20.32
22.	96.	15.	0.03	362.	8.3	20.17
23.	96.	15.	0.03	361.	8.5	20.02
24.	95.	15.	0.03	364.	8.6	20.16
25.	94.	16.	0.03	359.	8.8	20.20
26.	93.	17.	0.03	360.	8.9	20.16
27.	93.	18.	0.03	357.	9.1	20.03
28.	92.	18.	0.03	355.	9.2	20.24
29.	92.	19.	0.03	351.	9.4	20.29
30.	90.	20.	0.04	348.	9.5	20.29

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Flame retardant	Neoprene	Carbon dioxide
Smoke retardant	Ignition temperatures	Nitrogen oxides
Fire safety	Smoke	Hydrogen chloride
Polymers	Combustion products	Intumescent coatings
Polyvinyl chloride	Carbon monoxide	Fire-retardant coatings

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Experimental smoke-retardant PVC compositions and a reference base polymer were coated with alkyd- and epoxy-based intumescent paints. Specimens were tested in an NBS smoke density chamber under flame and nonflame exposure conditions. The smoke optical density, and the concentrations of CO, CO_2, NO_x, hydrocarbons, hydrogen chloride and oxygen were monitored during these tests.

Although the coatings reduced smoke formation from the base polymer, they had an adverse effect on the performance of the smoke-retardant compositions. The commercial coatings used in this work were found to generate significant quan-

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Item 20 Abstract (cont'd)

tities of smoke. Other, recently developed coatings will be used in projected work.

The intumescent coatings reduced the rates of carbon monoxide and hydrogen chloride formation, especially under nonflame exposure to a radiant energy source.

The coatings contributed small amounts of nitrogen oxides (NO_x) to the combustion products.